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U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
BULLETIN No. 3.

REPORTS

OF

OBSERVATIONS AND EXPERIMENTS

IN

THE PRACTICAL WORK OF THE DIVISION,

MADE

UNDER THE DIRECTION OF THE ENTOMOLOGIST.

WITH PLATES.

WASHINGTON:
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LETTER OF SUBMITTAL.

DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., October 10, 1883.

SIR: I have the honor to submit for publication the third Bulletin from this Division, prepared under your instructions.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. GEO. B. LORING,
Commissioner of Agriculture.

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PREFACE.

This Bulletin contains some recent notes on the Army Worm, especially with reference to its food-plants and to its injuries in the cranberry bogs of New Jersey during the summer of 1882, such injury by this insect not having been previously recorded. There are some additional experiments with pyrethrum, with a view of ascertaining its effect on different insects, and some notes on insects injurious to forest trees. All these notes were prepared for the Annual Report, but were necessarily excluded for want of space.

A report by Dr. E. H. Anderson of observations on the Cotton Worm the present summer in Southern Texas will prove interesting, as showing what is being done in that section, and as illustrative of the persistence of false theories long after they have been exploded. In his correspondence and earlier reports Dr. Anderson has always held to the view that the pupa of Aletia hibernates, and he has given in this report the testimony of several planters to that effect. We publish his report as it was written, as this is our rule in such cases, but we wish the reader to remember that the hibernation of the chrysalis has been definitely disproven, and that it is now an established fact that hibernation takes place in the moth state, and that the pupæ which fail to give forth the moth before severe frost invariably perish.

The machine described and illustrated in our last Annual Report for spraying cotton from below had been perfected to a large extent without accurate field test of its practical working. We very much desired, therefore, to learn whether any improvements could be made in its several parts or what faults it possessed as a working machine, and as soon as news came that the worms had begun to work around Selma, Ala., Dr. Barnard was sent down with the instructions which accompany his report. The advantages of the machine, and they are many, have already been set forth in the Annual Report for 1881–'82; but the report of Dr. Barnard would seem to show that considerable modification in the details, especially of attachment, is necessary. Future experience may lead to the abandonment of the attempt to spray cotton from the ground up, on account of the irregularity of the rows in the average cotton-field, and the adoption of lateral or oblique spraying from nozzles that do not drag entirely on the ground, but hang some inches above it. The objection which the average cotton-field offers will not hold so strongly in case of a crop of potatoes, where the plants are much lower and in much more uniformly-spaced rows. The results of Dr. Barnard's further experiments show that the objections to the

stiff connection, for the reasons set forth, may be overcome when in the cotton-field.

The late Dr. James S. Bailey,* of Albany, N. Y., was commissioned some time ago to prepare a full account for publication by the Department of the wood-boring lepidopterous larvæ of the family Cossidæ, as he had given much attention to this group and was familiar with all of the North American species. It was his intention to have prepared such an article, giving particular attention to life-habits. Unfortunately his health from the period of his instructions to his recent death was such that he was unable to fully carry out the plan, and we furnish the report incomplete and falling short of what it would have been had he lived. We publish it as it was written, and do not desire to be held responsible for his views. The principal species discussed, *Cossus centerensis*, was first described by Mr. J. A. Lintner in the *Canadian Entomologist* for July, 1877, where many of the facts were given that were detailed by Dr. Bailey in a later article in the same periodical for January, 1879, and in the report here published.

This Bulletin concludes with a report by Dr. William McMurtrie, professor of chemistry in the Illinois State Industrial University, upon certain measurements and tests made by him at our request to determine the relative fineness and strength of the fibre of samples of raw silk raised at the Department. A noticeable result of these experiments, as may be seen by reference to the accompanying tables, is that the fibre from worms fed exclusively upon Osage orange is shown to be somewhat finer, and, on the average, equal in strength to that obtained from the mulberry-fed individuals. We also give a plate from photographs taken by Dr. McMurtrie, illustrating the dual nature of the fibre.

C. V. R.

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* Dr. Bailey died July 1, 1883.

OBSERVATIONS AND EXPERIMENTS

IN

IN THE PRACTICAL WORK OF THE DIVISION.

FURTHER NOTES ON THE ARMY WORM.

In the last annual report of the Department we published the most important portion of the chapter on the Army Worm in advance from the Third Report of the United States Entomological Commission. In this article we give some additional notes, together with an account of the rather abnormal occurrence of the worms in the summer of 1882 in certain cranberry bogs in New Jersey.

THE ARMY WORM IN 1883.

In spite of the fact that the spring of 1883 was favorable for the development of the Army Worm, its scarcity almost all over the country has been remarkable. In few years within our recollection have there been so few complaints of damage by the worm. In fact, no well authenticated case of injury has come to our notice,* though in the latter part of June it was rumored to be present in force in Eastern Pennsylvania. In the vicinity of Washington, in localities where last year the moths were extremely numerous, but few individuals have been found.

EXPERIMENTS UPON FOOD-PLANTS.

The normal food-plants of the Army Worm are found among the grasses and grains, not a single species of either, so far as known, coming amiss. Wheat and oats seem to be their favorite among the small grains, though rye and barley are also taken with less relish. German millet, corn, and sorghum are eaten by the worms, particularly when young and tender. They were found in 1881 feeding to a greater or less extent on flax in Illinois, although this is mentioned by Fitch as one of the crops which the worms will not touch. They have also been reported to eat onions, peas, beans, and other vegetables, though probably only when pressed with hunger. As stated in our Eighth Missouri Report, upon the reliable authority of Mr. B. F. Mills, of Makanda, Ill., they have also been known to eat the leaves of fruit trees. Ordinarily clover is disregarded by the worms, though they occasionally nibble at it. A timothy field is often eaten to the ground, leaving the clover scattered through it standing. In this connection it may be well to

* Since this was written it has been reported as injurious at East Windsor, Conn., during June.

state that on the Department grounds at Washington the newly-hatched worms have been found in a folded clover leaf, feeding thus protected, and under such circumstances as rendered it probable that they had been hatched there.

Mr. Lockwood stated in his report (see last Annual Report of this Department) that even the common rag-weed (*Ambrosia artemisiæfolia*) was eaten clean by the worms, and also that the worms in passing through a strawberry patch devoured both the leaves of the plant and the unripe fruit.

In order to establish upon proper authority the facts concerning what the Army Worm will and will not eat when pushed by hunger, we conducted during the summer of 1881–'82 a series of experiments upon different plants, placing each plant in a separate breeding-cage with a few healthy half-grown larvæ. The results show an unexpected power of accommodation to plants in many families, and no resultant variation in the imagines worth mentioning.

The results are summarized below:

PAPAVERACEÆ.—*Papaver somniferum.* (Garden poppy.)

Of four larvæ all attained full growth and entered the ground. Three moths issued.

CRUCIFERÆ.—*Brassica oleracea.* (Cabbage.)

The four larvæ in this case moved restlessly about for the first day without feeding. The second day they began to feed, and by the fifteenth all had changed to pupa. In this state two died, but the other two issued as moths.

CRUCIFERÆ.—*Raphanus sativus.* (Raddish.)

Of four larvæ two lived to issue as moths; one died in the pupa, and one in the larva state.

MALVACEÆ.—*Gossypium herbaceum.* (Cotton.)

All died after feeding slightly.

VITACEÆ.—*Vitis labrusca.* (Grape.)

All died without feeding.

LEGUMINOSÆ.—*Pisum sativum.* (Garden pea.)

Of five larvæ, all fed abundantly; transformed and issued as moths.

LEGUMINOSÆ.—*Phaseolus vulgaris.* (Garden bean.)

All died without touching the leaves.

ROSACEÆ.—*Fragaria virginiensis.* (Strawberry.)

The four larvæ experimented on all fed for from seven to ten days and then died without transforming.

ROSACEÆ.—*Rubus strigosus.* (Raspberry.)

Of eight larvæ, all fed well and all transformed to pupæ; only four, however, issuing as moths.

UMBELLIFERÆ.—*Daucus carota.* (Carrot.)

The four larvæ begun feeding on the second day; all transformed; two died in the pupa state and the other two issued as moths.

UMBELLIFERÆ.—*Pastinaca sativa.* (Parsnip.)

Of four larvæ, one died before transforming, one in the pupa state, and the other two issued as moths.

COMPOSITÆ.—*Lactuca sativa.* (Garden lettuce.)

Of four larvæ, one was destroyed by the others before they commenced to eat; the others all fed to full growth, transformed, and issued as moths.

CHENOPODIACEÆ.—*Beta vulgaris.* (Garden beet.)

Of four larvæ, after feeding slightly, three died after six days; the remaining one fed more extensively, transformed to pupa, and issued as an apparently healthy moth.

LILIACEÆ.—*Allium sativum.* (Onion.)

All fed; two died as larvæ, and the other two completed the round and issued as moths.

CONIFERÆ.—*Abies canadensis.* (Hemlock.)

All died without feeding.

THE ARMY WORM IN THE CRANBERRY BOGS OF NEW JERSEY.

In June, 1882, there appeared on the Rockwood cranberry farm, near Hammonton, N. J., an insect enemy which, according to the reports received from Mr. Rockwood, first destroyed the rushes and afterwards the young cranberry vines, thus doing considerable injury. Specimens sent by Mr. Rockwood proved to be the larvæ of a species of saw-fly, which, however, in captivity refused to feed on the cranberry vines.

The following correspondence on this subject explains itself:

HAMMONTON, ATLANTIC COUNTY, NEW JERSEY,
July 4, 1882.

To the Entomologist, Agricultural Department:

SIR: I send by this mail a box of worms which have done me great damage on a cranberry bog. Some say that they are the Army Worm, but they did not come as an army. They are on several cranberry bogs around, but no one has seen them traveling. They are first found on *the bog*, and are found of all sizes, from ¼ inch long to 1½ inches, and appear to have been hatched where they are found. The young have only been seen on rushes in the ditches where water stands or was. The old spread over the bog, eating first in preference grass, and then attacking the vines. They eat the new, tender growth. The young are transparent and greenish, the full-grown blackish. The large are active, moving rapidly. When touched they drop off the vines and curl up. They work toward evening and apparently in the night. They were first seen about June 20. We have killed some with Paris green, but they seem to be disappearing, even where no Paris green has been used. We find dead bodies where we have not used the poison; but we still find the young and some old, although not as many as a few days ago. Please tell me what you know about them.

Respectfully,

CHAS. G. ROCKWOOD.

P. S.—We have been unable to find a grown one at the time of day we got those I send with this. They seem to touch nothing but grass and cranberry vines.

DEPARTMENT OF AGRICULTURE,
ENTOMOLOGICAL DIVISION,
July 6, 1882.

Mr. CHAS. G. ROCKWOOD, *Newark, N. J.:*

DEAR SIR: Your favor of the 4th instant, with accompanying box, duly to hand. The worms you send, and which are so destructive to your cranberries, are the larvæ of a saw-fly (family *Tenthredinidæ;* order *Hymenoptera*) belonging apparently to the genus *Dolerus.* I have found the same larva feeding on Juncus at Saint Louis, but it has not before been reported to attack cranberry plants. The subject is therefore of great interest to me, and you would greatly oblige me by sending on as many of the worms as you are able to find, packed according to the above-printed directions. I would also be thankful for any further observations you could furnish on the habits and development of this pest.

Yours, truly,

C. V. RILEY,
Entomologist.

NEWARK, N. J., *July* 7, 1882.

C. V. RILEY, Esq., *Entomologist, etc.:*

DEAR SIR: Your favor of the 6th received. I have written to my farmer to send you more specimens. We thought when I was there that the worms had nearly done their work; and at noon, when we tried to find them to send you, we could only find the old ones. I had earlier in the day found one old one, before I thought of consulting you. They had been on the land about two weeks, and at one time parts of the bog were black with them. Worms supposed to be the same had been on a neighboring bog two or three years ago, and disappeared about July 1. They have not been seen there either year since, although the owner thought he found their eggs. The same worms (so supposed) have been this year on farms 5 or 6 miles from us. They are also on the cranberry bogs near by us. We are in the pine barrens. The cranberries are surrounded with dikes or dams, so as to be completely covered with water in the winter, from, say, December 1 to May 10, more or less, according to seasons and according to the facilities of each location, each not having equal supply of water. We did not get ours fairly flowed last year till near the end of December. I think the water was off by May 10 or 12, having been let down gradually to addle the eggs of insects. We found on July 4, in searching for full-grown insects, dead bodies all in shape, but which when handled fell to pieces. I have told my farmer if he found others to send them to you.

The cranberry is an evergreen. The worms preferred grass and ate the grass growing among the vines first, and then took only the new this year's tender growth of the vines and the buds for this year's fruit, leaving the vines just as they were before the season's growth began. The old growth was not touched.

On the reeds where we found the young worms we found no evidence of the young worms eating the reeds. In one instance, near the worm, I noticed a little place three-eighths inch long where the reed had been gnawed, and it may have been done by the worm.

Respectfully,

CHAS. G. ROCKWOOD.

P. S.—As to the damage, about three-fourths of the buds for this year on my land have been eaten, and three-fourths of the new growth for next year's bearing. My crop will therefore be cut down three-fourths of the expected yield of 2,000 bushels.

The new growth has time yet to grow again and form buds for next year. That you may judge of the importance of this matter, I will say that the loss may be estimated in money at, say, $2,000.

DEPARTMENT OF AGRICULTURE,
ENTOMOLOGICAL DIVISION,
July 7, 1882.

MR. CHAS. G. ROCKWOOD, *Newark, N. J.:*

DEAR SIR: In regard to the saw-fly you sent me as injurious to cranberries, I will say that in my breeding jars they refuse to eat the cranberry plants. It now occurs to me that you may have possibly overlooked the real authors of the mischief, and that the saw-fly larvæ have merely fallen upon the cranberry plants from some other plant. I beg you now to ascertain whether the larvæ really *feed* on the cranberries. By doing so you will greatly oblige.

Yours, truly,

C. V. RILEY,
Entomologist.

NEWARK, N. J., *July* 10.

C. V. RILEY, Esq., *Entomologist:*

DEAR SIR: Your favor of the 7th instant has been received. There is no doubt that the worm of which I sent you the young did the mischief by eating the vines. I suppose that my farmer happened to put in the box only old cranberry vines. They do not touch the old vines, but eat the young shoots off this year's tender growth, and only after exhausting the supply of grass which grows among the vines. But eating the new growth takes the fruit buds and destroys this year's crop, and takes also the growth which is to bear next year. The worms *undoubtedly* feed upon the vines. They leave upon the ground many leaves, but must consume largely.

When I was there, in spots not reached by the worms the new growth arose solid above the old vines, say, 4 inches, so that nothing else could be seen. On the other side of the ditch would be a patch eaten clean down to the old vines, leaving them as they were when the water was taken off and before new growth has started, and the whole patch 4 or 5 inches lower in solid growth than the untouched patch adjoining, and of different color.

Respectfully,

CHAS. G. ROCKWOOD.

We visited Mr. Rockwood, at Newark, N. J., shortly after the receipt of his last letter, and concluded from further information obtained that the saw-fly larvæ were certainly not the authors of the mischief, but that the Army Worm in all probability did the damage. Yet, as doubt remained, we were anxious to settle the question, and sent Mr. E. A. Schwarz to make examination on the spot. The following is the report of his observations:

SIR: In accordance with your directions I have made a study of the injury done to Mr. Rockwood's cranberries as far as it was possible at the time, the insect that did the damage having disappeared more than six weeks previous to my visit at Hammonton.

The Rockwood cranberry farm is divided into squares, each of about 50 acres, surrounded by high dikes, and intersected by numerous irrigation ditches. Two or three other squares are just being constructed, but are not yet inclosed with dikes. The cranberries being fully formed at the time of my visit, August 1, there was no difficulty in taking in at a glance from the high dikes the extent of the damage done by the insect. It was apparent that the damage was confined to a number of the smaller squares formed by the irrigation ditches. On some of these hardly any berries were to be seen, while other squares adjoining the damaged ones, and only separated from these by the narrow ditch, were not injured at all. On the newly-constructed squares, where there is an abundance of grass, the newly-planted vines had severely suffered.

There is but little grass on the cranberry bogs under cultivation, and it was found that those squares had suffered most on which there was most grass, while on those squares where the cranberry vines had nearly exterminated the grasses very little or no damage at all had been done.

No living specimens of the insect that really did the damage could be found, as was to be expected after the lapse of more than six weeks, the worms having been seen on the bog about June 20; but the following traces thereof were discovered: 1. The ground on the damaged squares was literally strewn with excrement, which, though much decomposed at this time, was unmistakably that of a Lepidopterous larva; 2. Numerous heads of a Noctuid larva were found on the ground, most of them in a badly decomposed state, and but a few among them in fair condition. These heads were so abundant that there could not be the least doubt that they belonged to the destructive larva. The Sarracenias growing in some places in the bog each contained numerous specimens of the decomposed larvæ, but in the course of the examination a few fairly well preserved specimens were found; 3. Of pupæ, or rather empty shells, very few could be found, and it appears that the wet ground had prevented the worms from entering the same, and that they mostly perished above ground without transforming; 4. A number of empty Microgaster cocoons, indistinguishable from those of *M. congregatus*.

I will also remark in this connection that I found two specimens, the only ones I saw, of the saw-fly sent by Mr. Van Hise as the originator of the damage. It was feeding on a species of Scirpus (?) which grows in the irrigation ditches.

The cultivated bog is flooded with water during winter and spring to a depth of several feet, so that no Lepidopterous larvæ can hibernate in it. The uncultivated part is also under water most of the time mentioned, but not so thoroughly as the cultivated portion. Outside of the cranberry lands there is but little graminaceous vegetation in the pine barrens. On the 10th of May the water is drawn off from the bog, an operation which is accomplished in little more than 24 hours. After this the cranberry vines and other vegetation start vigorously, the grasses, one or two species of which grow in thick bunches, being there much fresher than anywhere else in the neighborhood.

From Mr. Rockwood's and Mr. Van Hise's observations there can be no doubt that the larvæ first devoured every blade of grass on the squares where the eggs were deposited and that they afterwards, from mere want of other food, began to attack the cranberry vines. They destroyed only the young vines (*i. e.*, those which should have been bearing this and the next seasons), eating the young, fresh leaves before these had fairly opened. At the time of my visit these young twigs had the appearance of being cut with a knife. Mr. Van Hise further states that he saw the worms appear in great numbers at the edge of the irrigating ditches, a great many of them being in the water and on the rushes growing in the ditches. This observation is no doubt correct, as the worms, after passing through one of the squares, finally congregated at the edge of the irrigating ditch and tried to get across, and in doing so got at the rushes, which at the time of my visit still bore evidence of their attack. In general the irrigation ditches were evidently an effectual barrier against the progress of the worms, and whether they succeeded, in one or two instances, in crossing the ditches, or whether the damage on the adjoining squares was caused by worms that hatched on the same, could not be ascertained. At any rate their feeding on the rushes in the water was the reason of the confusion in regard to the saw-fly larvæ. Mr. Van Hise, being instructed to collect specimens of the cranberry enemy at a time when the real depredators had disappeared, naturally did not find any other worms on the rushes than the saw-fly larvæ, which seem to have been very numerous in the beginning of July.

In regard to other injurious insects observed by me on the cranberry bogs, I would mention that at the time of my visit serious damage was done by various species of locusts (*Acrididæ*), by eating large holes in the berries. Mr. Van Hise resorts to the

following remedy against this pest: In company with another person he drags a long rope across the bog, thus driving away many of the locusts, or at least disturbing them. He says that if this operation were repeated about twice each day the damage would be considerably reduced, as the disturbed locusts do not settle down again to their destructive work until after the lapse of several hours.

No "berry moth" could be observed on Mr. Rockwood's cranberry farm, but considerable damage had been done earlier in the season by another Tortricid larva, which webs together the terminal leaves of the young vines. At the time of my visit not a single living specimen could be found, but I believe that an additional flooding of the bogs would prove a good remedy for this pest.

Respectfully,

E. A. SCHWARZ,
Assistant.

Prof. C. V. RILEY,
U. S. Entomologist.

A careful examination of the more or less irrecognizable specimens found by Mr. Schwarz left little doubt in our minds that the species was the genuine Army Worm, a few of the heads making this decision possible.

It is evident from the facts observed by Mr. Schwarz that the moth had flown from some distance, for the records for that year, as indicated in our last report, show that the insect was quite prevalent throughout that portion of the United States at the time.

REMEDIES.—It follows from the facts obtained that one of the best ways of preventing injury to cranberries in the future is to keep the bog as free as possible from foreign plants, and that the injury may be limited by increasing the number of irrigating ditches and by keeping these free from weeds and other obstructions.

Another method to prevent the recurrence of such invasion of the Army Worm suggest itself: The water is drawn off from the bog on May 10, and the plants not flooded again for the rest of the season. The irrigating ditches are then only kept filled with water in given quantities, according to the character of the season. Now, the water can be drawn off earlier than has hitherto been done, without injury to the plants, and, what is more important in this connection, the water can be let on again without injury to the plants at any time before blooming, *i. e.*, about the last week of June. If the eggs are laid by the moths, as was evidently the case in 1882, during the month of May, it is apparent that a flooding of the bog some time during the month of June (the water to be kept on the bog, say, for about two days) would drown out the worms before they have begun to do the damage.

Wherever an abundant water supply is at command in spring and early summer, and under control, as is the case on the cranberry farms near Hammonton, a repetition of the damage done by the Army Worm could thus easily be avoided. Should the worm appear during or after the blooming season little or nothing could be done against it; but it is probable that at this time the damage done by the worms would be much less serious than earlier in the season, as the leaves on the bearing vines will then be too hard to be very attractive.

EXPERIMENTS WITH PYRETHRUM.

We treated so fully of this insecticide in our annual report for 1881–2 that the value of the powder and the modes of using it are now pretty well understood. The following account of experiments made by Mr. Howard will, however, prove interesting, as we had them instituted in order to show how the different larvæ experimented with were severally affected by it.

1. SPECIAL EXPERIMENT WITH CUTLERS' POWDER NO. 1.

September 20, 11.45 a. m.—Three healthy, half-grown larvæ of the Fall Web-worm (*Hyphantria textor*) placed in small glass tumbler, and a very small quantity of Cutlers' No. 1 puffed on the anterior abdominal segments of each; tumbler covered with glass slip.

In four minutes one seemed affected; moved the head quickly from one side to the other, arched the back, and made rapid jumping movements as if trying to get rid of the powder. In 6 minutes all were similarly affected. At 7 minutes the one first mentioned was struggling violently and incessantly, jumping and writhing the whole body, now on its back and again on its side; no intervals of rest except momentary in this extremely rapid motion.

In ten minutes became quieter, but was still bending the body in all directions; incessantly writhing like a mammal poisoned with strychnine.

12.2.—Motions have become more spasmodic and jerky, and have lost to certain degree the smoothly writhing character.

12.10.—Motions much slower and consist of a slow writhing of the whole body.

12.18.—Motion still slower; the true legs trembling violently at intervals.

12.28.—The motion of the body has become very slow, but the legs are constantly twitching. The rectum is somewhat everted and the abdominal segments have become somewhat contracted.

12.50.—The body is still more contracted, though still moving slightly, the legs still trembling somewhat.

1.40.—The abdomen is still more contracted, but a slight motion is left, which shows that the final paralysis is that of exhaustion rather than of tetanus.

2.00.—Apparently almost dead; only a slight occasional motion of prolegs and mouth parts, with an occasional twitch of one of the true legs.

3.20.—A very slight motion still perceptible; the bodies have shrunken to very small proportions.

September 21, 9 a. m.—Still a slight motion of legs and mouth parts, and one moves also one of its prolegs.

1.15 p. m.—No change.

3.00.—Still no change.

September 22, 9.30 a. m.—No motion left except a very slight occasional twitching of the anterior prolegs.

2. PARALLEL EXPERIMENT IN OPEN AIR.

September 20, 11.45 a. m.—A larva similar in all respects to the preceding was dusted in the same manner with the same powder, in the same quantity, at the same time.

In 10 minutes it began to show signs of uneasiness. In 13 minutes began to struggle. The spasms increased in violence until 12.50 when they began to subside. There were still strong writhings at 3.30, and the body had only just begun to contract; while the confined worms had reached a similar condition at 12.30.

At 9 a. m., *September* 21, the body had shrunken enormously, but there was still motion of the entire body.

3.30 p. m.—No perceptible change.

September 22, 9.30 a. m.—Dead. This seems strange in view of the fact that the confined larvæ which were strongly influenced by the powder at a much earlier period are still alive.

EXPERIMENTS 3 AND 4.

The following experiments were made with nine samples of powder: 1st, the ordinary powder sold by Cutler Bros. & Co., of Boston, next, five samples labeled Cutler Bros. No. 1, No. 2, No. 3, No. 4, and No. 5, sent to the Department for comparative test; 7th, pyrethrum imported by Lehn & Fink, of New York City, in 1881; 8th, the 1882 importation of the same firm; and, 9th, a powder made from flowers raised by Professor Riley in 1882.

In experiment 3, six young larvæ of *Hyphantria textor*, about one-fourth grown, were placed in each of nine labeled, closed tin boxes (11×8.5×3.5 cm.), and a small quantity of each sample of powder was dusted on the dorsum of the anterior abdominal segments of the worms in each box.

In experiment 4, three half-grown larvæ of the same insect were used in the same boxes and dusted in the same manner. Each worm received, as nearly as could be judged by the eye, the same quantity of the powder.

EXPERIMENT No. 3.

	Cutler Bros.' ordinary.	Cutler Bros.' No. 1.	Cutlers' No. 2.	Cutlers' No. 3.	Cutlers' No. 4.	Cutlers' No. 5.	Lehn & Fink, 1881.	Lehn & Fink, 1882.	Riley.
SEPTEMBER 20. (Placed in box at 1.50 p. m.)									
At 2.15 p. m.	All writhing violently.	Still writhing violently, but quieter than preceding	Still struggling, but feebler even than preceding.	All writhing violently.	All writhing violently.	All writhing violently.	All writhing violently.	All writhing violently.	All writhing violently.
2.45 p. m.	All much quieter.	All much quieter.	All much quieter; more so than preceding.	Much quieter: as much so as preceding.	Much quieter.	Still writhing strongly; appear not so badly affected as preceding.	Still struggling.	One small one has almost ceased struggling. The larger ones are still in incessant motion.	No very marked change; the struggles are not quite so violent.
3.45 p. m.	No appreciable change.	More affected than preceding; scarcely any motion.	Very badly affected; almost motionless, except in limbs.	Condition almost identical with preceding; if anything, slightly less affected.	Still quieter ..	In about same condition as preceding.	Have become quieter.	Still a slight motion of the whole body.	About the same as preceding; rather more motion.
SEPTEMBER 21.									
9 a. m.	All dead but one, which seems to have entirely recovered.	**All dead**	**All dead**	**All dead**	**All dead**	All dead but one, which shows faint signs of life.	**All dead**	**All dead**	**All dead.**

SEPTEMBER 20. (Placed in box at 11.15 a. m.)									
11.30 a. m.	All in violent convulsions.	All in violent convulsions.	All in violent convulsions.	Not yet convulsed.	Two in violent convulsions: one not yet seized.	Slightly convulsed.	Convulsions beginning; quite strong.	Convulsions not yet begun.	All in violent convulsions.
12.20 p. m.	Two have become quiet and are badly affected; one crawls rapidly, without spasms.	Two have passed through the spasmodic stage; one still struggling violently.	All apparently just passed through violent stage.	All just finished violent stage.	One apparently normal; two still violent.	All finished the violent stage.	One still normal; one still violent; one passed the violent stage.	All finished the violent stage.	All finished the violent stage.
1.25 p. m.	One normal; two more quiet and beginning to contract.	One normal; two more quiet and beginning to contract.	All quiet; one worse than others.	No marked change; quieter.	No change....	Feebler, tho' not markedly so.	No change....	One appears to be recovering; two quieter.	All considerably feebler.
3.20 p.	One normal; one appears as if recovering; one feeble, but still alive.	The normal one taken with spasms; two more contracted and feebler.	No marked change; all much shrunken.	No marked change; all somewhat shrunken.	One normal; two quieter and beginning to contract.	All much feebler and shrunken.	One normal; two shrunken, but still strong.	One almost recovered apparently; two shrunken and very sick.	All shrunken and feeble, but not so much so as preceding.
SEPTEMBER 21.									
9 a. m.	One normal; one slightly moving; **one dead.**	One just alive; **two dead.**	All alive, though feeble.	One strong, recovering; one shrunken and feeble; one almost dead.	One just alive; **two dead.**	**All three dead.**	One still normal; **two dead.**	One very sick; one almost gone; **one dead.**	One very feeble; **two dead.**
1.05 p. m.	No change.....	No change	One just alive; **two dead.**	One recovering; one very feeble; one almost dead.	**All dead**....	.....	The last one taken with convulsions.	One almost gone; **one more dead.**	No change.
3.30 p. m.	No change.....	No change.....	**All dead**.....	One almost gone; **two dead.**	.....	.....	Still struggling.	One still alive.	No change.
SEPTEMBER 22.									
9.30 a. m.	One lively, but starved, not affected; **one more dead.**	**All dead**.....	.....	**All dead**.....	.....	.....	Still alive, though feeble.	**All dead**	**All dead.**

EXPERIMENT NO. 5.

September 22.—Twelve larvæ of *Plusia brassicæ* and four of *Pionea rimosalis* were placed in one of the tin boxes and sprinkled in the usual manner with Cutlers' No. 5, the powder which had given the best result in the last experiment.

In 5 minutes the Pionea larvæ were affected, and in 10 minutes the small Plusias; the full-grown Plusias not until 25 minutes. The effects upon all were very marked. The rectum was everted, and large quantities of a greenish liquid were ejected from the mouths of the Plusias.

At 35 minutes two of the largest Plusias still appeared normal. The skin of the Plusias being so delicate the heart beat was watched without much difficulty. In the normal individuals the pulse was found to range, after numerous trials, from 44 per minute to 68, averaging about 56.

The pulse of one of the large worms in its first spasms marked 164, and 8 minutes later it had fallen to 150, and in 15 minutes later still to 140.

In a smaller one, which had passed through the first convulsions and had become feeble, the pulse was almost imperceptible from weakness, and though still very fast (136 per minute) had evidently fallen.

At the expiration of 18 hours the Pioneas were all dead, and 4 of the smaller Plusias were also dead. Two of the Plusias had spun up and the remaining 6 appeared perfectly healthy and normal. The pulse of these last varied from 44 to 64.

September 24.—Three more of the larvæ spun up, and the first two transformed to healthy pupæ.

September 25.—The three larvæ which spun up on the 24th have transformed to healthy pupæ.

September 27.—The remaining larva which recovered from the dosing is still strong and active.

September 28.—This larva has also spun up and transformed to a healthy pupa.

EXPERIMENT NO. 6.—EXPERIMENT WITH CUTLERS' "SPECIAL INSECT POWDER FOR ROACHES AND WATERBUGS."

The base of this powder is Dalmatian pyrethrum, but from the odor it apparently contains some red pepper.

September 22.—A full-grown larva of *Hyphantria textor* was placed in a closed glass jar and thickly dusted with this powder, which stuck to the hairs in masses. It was seized with no convulsions, and September 27, after 120 hours, is still alive, though much shrunken and feeble from starvation. The powder apparently had no effect upon it.

September 22.—Four full-grown cockroaches were placed under an inverted tumbler, and a small quantity of this powder puffed in from an insufflator. In 15 minutes all were taken with spasms, and in an hour

were lying helpless upon the table, although still retaining considerable vitality. In twenty hours they were dead.

EXPERIMENT NO. 7.—EXPERIMENT UPON LARVÆ OF DATANA MINISTRA.

This experiment was conducted in the same manner as Experiment No. 4. Three full-grown larvæ of *Datana ministra* were placed in each of nine tin boxes and sprinkled in the same manner with the same amount of the different poisons. The boxes this time, instead of being covered with their own tight tin covers, were covered with slabs of glass, which, on account of the irregularities in the edges of the boxes, did not fit tightly, and allowed for a pretty free circulation of air. But this perhaps was compensated for by the fact that the covers did not have to be lifted to observe the condition of the larvæ. The fact should be remembered in comparing this experiment with No. 4. The following table shows the result, and it will be noticed that the *Datana* is susceptible in a remarkable degree to the action of the pyrethrum when compared with *Hyphantria* or *Plusia:*

EXPERIMENT No. 7.

	Cutler Bros.' ordinary.	Cutler Bros.' No. 1.	Cutler Bros.' No. 2.	Cutler Bros.' No. 3.	Cutler Bros. No. 4.	Cutler Bros.' No. 5.	Lehn & Fink, 1881.	Lehn & Fink, 1882.	Riley.
SEPTEMBER 28. (Placed in box at 10.25 a. m.)									
10.40 a. m	Uneasy; no spasms as yet.	Two in spasms; one uneasy.	Very restless; one in spasms.	All three vomiting; one in spasms.	One only in spasms.	One in spasms; vomiting green liquid copiously.	All restless and trying to eat off the powder.	Same as preceding.	Not yet affected.
10.55	Two in spasms; the other quite normal.	No great change.	All three in spasms.	All three in spasms.	All three in spasms.	One in spasms; the others vomiting.	One in spasms; the others unchanged.	Precisely same as preceding.	One beginning to vomit.
11.50	**One dead**; two still struggling.	**One dead**; one very sick; one still struggling.	**One dead**; the others very sick.	**All three dead**, without contraction.	**One dead**, without contraction; the others quiet.	**One dead**; two contracted much, but still alive.	Two in spasms; one nearly normal.	All three in spasms.	All three in spasms.
1.50	**Two dead**; the last one nearly.	**Two dead**; the last one almost.	The remaining two seem almost gone.		**Two dead**; the last one nearly.	**All dead**	All alive, but nearly gone.	All apparently nearly gone.	**One dead**; two just alive.
3.30	No change	No change	No change		No change		No change	No change	No change.
SEPTEMBER 29.									
9 a. m	No change	No change	No change		No change		All still alive.	**One dead**; two still moving somewhat.	**All dead.**
SEPTEMBER 30.									
9 a. m	**All dead**	**All dead**	No change		No change		No change	**Two dead.**	
OCTOBER 1.									
9 a. m			**All dead**		**All dead**		**All dead**	**All dead.**	

EXPERIMENT NO. 8.

September 28, 10.50 a. m.—Seventeen full-grown larvæ of *Datana ministra* placed in a large breeding-cage open at top, and a small quantity of Cutlers' No. 5 blown in through an insufflator, making an atmosphere of dust.

11 a. m.—Some half dozen are writhing uneasily.

3 p. m.—Four are in convulsions.

September 29, 10 a. m.—Two are practically dead, only a slight motion of the thoracic legs remaining; two more on their backs, and only moving slightly. The rest are evidently somewhat affected, but retain their normal position, and are capable of strong motion.

3.30 p. m.—One dead; five others badly affected.

September 30, 9 a. m.—No change.

October 1, 9 a. m.—Five more dead.

October 2, 9 a. m.—Six more dead. The others appear perfectly normal.

NOTE.—This experiment possesses much interest when compared with experiment 7, as indicating the effects of the powder in a tightly-closed box and in an open cage, the latter approaching open-air conditions.

EXPERIMENT NO. 9.

September 29, 2.30 p. m.—A limb of hawthorn in the open air crowded with the Hawthorn Schizoneura (*Schizoneura lanigera?*) puffed upon copiously with Cutlers' No. 5, so that every individual must have had a dose.

October 1, 9.30 a. m.—Could see no effect whatever. The lice were just as numerous and just as healthy.

NOTES ON FOREST-TREE INSECTS.

By A. S. Packard, Jr., M. D., *Special agent of the Division.*

AFFECTING THE CEDAR OR ARBOR VITÆ.

EUPITHECIA MISERULATA Grote.

Although the moth is very common, occurring all over the Eastern United States, flying about and entering our houses through the summer, the caterpillar is rarely met with, though it is liable to prove locally injurious to cedar hedges and ornamental trees. We have reared the moth from caterpillars found on the low bush juniper (*Juniperus communis*), and descriptions of the larva and chrysalis will be found in Bulletin 7 of the U. S. Entomological Commission, p. 248. The following descriptions were drawn up from a specimen living during the last week of August, the chrysalis appearing September 30 on the cedar in Maine, the moth appearing the following spring, early in May, in confinement:

Larva.—Body slender, the sutures between the segments well marked and stained with yellow. The head small, rounded, not bilobed, and not so wide as the body. Uniformly pale green, exactly concolorous with the leaves of the cedar, on which it feeds. The lateral fleshy ridge of the body is marked with greenish-yellow, forming a prominent, interrupted, greenish-yellow lateral line. Supra-anal plate very short, smooth, obtuse at the apex, the edges marked with greenish-yellow. Anal legs thick and short, not broad; no dorsal warts or tubercles, the body being smooth. Length 12^{mm}.

Pupa.—Green, slender. Length 7–8^{mm}.

AFFECTING THE FIR, SPRUCE, AND HEMLOCK.

EUPITHECIA LUTEATA Pack.

This is a common caterpillar on evergreen trees, excepting the pine, and is described in Bulletin 7, U. S. Entomological Commission, p. 237. The caterpillar is rather flat, the surface granulated, the body reddish and bearing a remarkable resemblance to a red, dead fir leaf. It turns to a chrysalis late in August and early in September in Maine, and the moth appears the following May and June.

The moth differs from *Eupithecia miserulata* in the much longer, more pointed fore wings. The palpi are also larger, acute, and black. It has four regularly-curved, parallel black lines on both wings; it is also characterized by the broad, clear, flesh-yellow or luteous band situated between the discal dot and the extra-discal line. Expanse of wings 22^{mm}.

AFFECTING THE PINE.

THE PINE CARIPETA.

(*Caripeta angustioraria* Walk.)

This is frequently met upon the white pine (*Pinus strobus*) in August and September throughout the New England States, and as late as the first week in October in Rhode Island. Specimens become full-fed by the 8th of August in Maine, and before entering the chrysalis state spin a whitish web, with minute meshes, not a loose web. On the day following the chrysalis appears, and the moth appears in May and June of the following year. It is one of our most showy geometrid moths.

The larva.—Body rather large and thick, thickest on the segment bearing the first pair of abdominal legs. Head nearly as wide as the prothoracic segment, very slightly angulated on each side of the vertex, mottled with dusky spots or marbled with transverse, parallel waved lines. The prothoracic segment rather small, not angulated in front, provided above with small warts. On each abdominal segment a high, transverse, prominent, smooth ridge, somewhat saddle-shaped and bearing at each end a piliferous wart. On the third and second segments from the end no such ridge, these being replaced by piliferous warts, the two on the penultimate segment being rather high and situated near together. Behind these two tubercles on a transverse wrinkle are two small dark warts, and on a succeeding wrinkle are six warts. On the supra-anal plate are four warts, and on the end, which is obtuse, are four small hair-bearing warts. There are similar hairs on the edge of the anal legs, which have a deep crease parallel to the front edge; the lateral ridge is large and rough and interrupted at the segments. The body elsewhere is variously tuberculated, with hairs arising from the warts. The body in general is pale whitish-gray, with a lilac tint or slate color, variously marbled with dark-brown and sometimes with a decided reddish tint. Length 32^{mm}.

Pupa.—Rather stout. Brown, with an obscure dorsal row of irregular spots forming a nearly continuous line or band: a lateral row of large, obscure spots; second abdominal segment from the end of the legs with two warts beneath. Length 15^{mm}.

The moth.—It differs remarkably from any other species of the family by the rich, opake, velvety, ochreous fore wings, with the three broad silvery lines and large discal dot. The head, antennæ, and thorax are pale ochreous. Fore wings opake, deep ochreous, paler at the base: on the inner fourth is a white line forming a single large and acute angle on the median vein, along which it is prolonged beyond the basal third of the wing, extending out nearly as far as the discal dot, though situated below it. There is a large, irregular, silvery-white discal dot and just beyond a broad silvery line, diffuse on the outside; it curves inward just below the median vein and slightly inward opposite the discal dot. Half-way between this line and the outer edge of the wing is a row of irregular white spots, from which sometimes run whitish streaks to the fringe, which between the white spots is ochreous-brown. The hind wings are pale whitish-ochreous above; beneath, washed with yellow-ochreous upon and on each side of the venules. Expanse of wings 36^{mm} (1.60 inches).

AFFECTING THE OAK.

THE OAK-LEAF CRYPTOLECHIA.

(*Cryptolechia schlagenella* Zeller.)

This is a remarkable insect, both as a caterpillar and moth. It is not uncommon in the larval state on the oak, where we have seen it in Maine

and Rhode Island in September. It feeds between the leaves, drawing them together with silk threads. When about to pupate it turns over a portion of the leaf nearly an inch long, lines the interior of the cell thus made with silk, and the moth appears the following spring. We have compared the moth with a type specimen sent to us by the late Prof. P. C. Zeller several years ago, and now in the museum of the Peabody Academy of Science, Salem, Mass., and it is undoubtedly that species, though the row of blackish dots so distinct in the fresh specimen reared by us is not to be seen in the type specimen; otherwise it agrees exactly with the latter. It is not an uncommon insect, but, so far as known, more curious than destructive, though it may at times disfigure the leaves of valuable shade trees.

The larva.—Head large, broad, and flat—as broad as the prothoracic segment; pale horn or whitish color, surface rough; in front crossed by two dark reddish-brown broad lines which form two large shallow scallops; the front line extends along the sides, including the eyes and the front edge of the clypeus; the other is broader, forming two scallops and crossing the apex of the clypeus. On each side of the head below the front line is a short, nearly straight, brown-black line not reaching as far as the eyes. The median suture of the head is rather deeply impressed; the vertex on each side is a little swollen and marked with eight or nine dark reddish-brown more or less confluent spots. The posterior edge of the head is edged with black-brown. The body is somewhat flattened, pale pea-green, a little paler than the under side of the leaf. Prothoracic segment without a shield, but broad, flat, and green like the rest of the body. On the sides of the three thoracic segments is a dark tubercle tinged with reddish between, forming a lateral thoracic line. No dorsal tubercles, but pale hairs, as long as the body, arise from minute points, which are obscurely indicated. Length, 23mm.

The pupa.—Body very thick and stout: the head broad, and the abdomen short and thick: the end of the body very blunt, the tip broad and obtuse, somewhat tuberculated, not spined. The wings reach to the end of the fifth abdominal segment, and on the under side of the sixth and seventh segments are two dark, ventral, small callosities; the tip is broad, truncated, rough, and dark. Length 10mm; thickness 3.5mm.

The moth.—A very large species for the family to which it belongs. Head with the scales between the antennæ and on the vertex loose and thick, not smooth as in Gelechia. Palpi long and slender, smooth, the third joint very long and slender, over one-half as long as the second. It is so large and the fore wings so broad and oblong, that at first it might be mistaken for a Tortrix.

Body and wings snow-white. Fore wings snow-white with two smoky, twin dots at the base of the wing near the costa; two smoky spots inside of the middle of the wing on the internal edge. Beyond the middle of the wing are five or six indistinct, pearly, smoky spots, the central one apparently forming the discal dot. Two faint, curved, smoky lines parallel with each other and with the outer edge, neither of them reaching the costal edge of the wing, and the inner less than one-half as wide as the outer. On the outer edge of the wing, on the white fringe, is a row of about five conspicuous dark brown spots; the base of the fringe is smoky, forming a faint line. Body, hind wings, abdomen, and legs snow-white; antennæ light brown. On hinder part of the thorax, very distinct when the wings are closed, is a large prominent tuft of broad brown scales, which send off different metallic colors, especially steel-blue. Length of body 9–10mm; of fore wing 11mm; expanse of wings 24mm.

FURTHER FACTS REGARDING THE EXTENT OF THE RAVAGES OF THE SPRUCE BUD-WORM IN MAINE.

The following facts regarding the extent of the ravages of this caterpillar on the coast of Maine were gathered during the summer of 1883, and for want of space omitted from the report published in that of the Entomologist of the Department of Agriculture.

The westernmost locality at which the spruce bud-worm was observed was on Peak's and other islands in Portland Harbor, the spruce not extending in any great quantity west of that city. The spruces about Sebago Lake were also destroyed by this worm or a similar caterpillar, in 1878, as we are informed by Rev. Mr. Kellogg, a Mr. Townsend being his authority. Around the shores of Casco Bay and on many of the islands, especially Birch Island, Orr's Island, Jewell's Island, and Great or Harpswell Island, also on Harpswell Neck, Mere Point, Prince's Point, as well as other peninsulas extending into Casco Bay, wherever the spruces and firs grow thickly, extensive areas of these trees were observed; also similar masses of dead spruce were observed along the Maine Central Railroad, from Portland to Brunswick, and thence to Bath; also on the shores of Cathance River, at and near Bowdoinham, Me. Wherever the fiords or narrow bays and reaches extend inland, in Cumberland and Sagadahock, as well as Lincoln Counties, the spruce and fir forests clothing their shores had been invaded by this destructive caterpillar. Wherever the spruces were abundant on the Kennebec River, below Bath, particularly on the eastern side, at and near Parker's Point, and also at and west of Fort Popham, there were extensive patches of dead spruces. Similar but smaller masses of dead spruce were observed along the steamer route from Bath to Boothbay Harbor, at and to the eastward of Southport; none were observed on Mouse or Squirrel Islands. In the course of a journey, at the end of July, from Brunswick along the coast to Eastport, we were able to ascertain the eastern limits of the ravages of this worm. Several clumps of spruces which had just died were seen on the Knox and Lincoln Railroad before reaching the Wiscasset Station. At Waldoboro', southeast from the station, was an extensive area of dead spruces which presented the same characteristic appearance as in Cumberland County, and for two or three miles beyond Waldoboro' there were to be seen large masses of dead spruces and firs. Beyond Warren no dead spruces were to be seen; none were observed about Rockland, Camden, Blue Hill, or the islands of Penobscot Bay; none on Mount Desert, or the islands from Mount Desert to East Machias, nor on the road from East Machias to Lubec, although the predominant growth is spruce. No dead spruces were to be seen about Eastport, nor along the Saint Croix River, to Calais, and none along the railroad from Saint Stephens to Vanceboro' and thence to Bangor. From personal observation and inquiry it is safe for us to report that east of the Penobscot River, in eastern Maine, south of Aroostook County, there are no areas of dead spruce. Returning to

Brunswick from Bangor, the characteristic patches or large clumps of dead spruce and fir were not seen until we reached a point south of Richmond, and near Bowdoinham, on and near tide water on the Cathance River. The general absence of any extensive areas of dead spruces around the Rangeley Lakes and the White Mountains has already been referred to in our report. It thus appears that the injury from this worm has been confined, at least south of Aroostook County, to an area on the coast extending from Portland to Warren, and extending but a few miles inland from the sea or tide-water.

The injury resulting from the attacks of the bud-caterpillar are characteristic, as we have stated, the trees dying in masses or clumps of greater or less extent, as if the moths had spread out from different centers before laying their eggs and the caterpillars, hatching, had eaten the buds and leaves, and caused the trees to locally perish. From all we have learned the past season we are now convinced that the spruce budworm (*Tortrix fumiferana*) is the primary cause of the disease on the coast. As remarked to us by the Rev. Elijah Kellogg, of Harpswell, Me., who has observed the habits of these caterpillars more closely than any one else we have met; where the worms have once devoured the buds the tree is doomed. This, as Mr. Kellogg remarked, is due to the fact that there are in the spruce but a few buds, usually two or three at the end of a twig; if the caterpillar destroys these the tree does not reproduce them until the year following. If any one will examine the buds of the spruce and fir they will see that this must be the case. Hence the ease with which the attacks of this caterpillar, when sufficiently abundant, destroy the tree. We have not noticed that the spruce and fir throw out new buds in July and August after such an invasion, the worm disappearing in June. On the other hand, the hackmatack or larch when wholly or partly defoliated by the saw-fly worm (*Nematus*) soon sends out new leaves. By the end of August we have observed such leaves about a quarter of an inch long. In the following spring a larch which has been stripped of its leaves the summer previous will leave out again freely, although the leaves are always considerably, sometimes one-half, shorter. Now, if any one will examine the leaf buds of the larch it will be seen that they are far more numerous than in the spruce and fir or other species of the genus *Abies*, being scattered along the twig at intervals of from a line to half an inch apart. Hence the superior vitality of the larch, at least as regards its power of overcoming or recuperating from the effects of the loss of its leaves in midsummer. Besides this, the bud-worm of the spruce and fir is most active and destructive in June, at the time the tree is putting forth its buds, while the hackmatack, which drops its leaves in the autumn, has become wholly leaved out some weeks before the saw-fly worms appear. For these reasons, while the spruce and fir usually die if most of the leaves and buds are eaten after the first season's attack, the larch may usually survive the loss of leaves for two seasons in succession.

In addition to the facts regarding the great abundance of the bud-worm we may cite information given us by Prof. L. A. Lee, of Bowdoin College, who observed the bud-worms in June, 1880, upon the spruces at Prince's Point, Brunswick, and had no doubt but that they were sufficient to cause the death *en masse* of these trees. In 1883 we visited the locality, and many of the trees had been cut down for fuel.

From Rev. Mr. Kellogg we learned the following interesting facts regarding the appearance of a similar, most probably the same, species of caterpillar, even upon the same farm that was ravaged in 1878, early in this century. According to Capt. James Sinnett and Mr. John Jordan, of Harpswell, the spruces of Harpswell and Orr's Islands were destroyed in 1807. Captain Bishops, whose son made the statement to Mr. Kellogg, cut down the dead spruces on these islands and worked six weeks boiling the sea-water with fuel thus obtained, in order to make salt. This was during the embargo which lead to the war of 1812 with Great Britain. It is interesting to note that the bud-worm in 1878 appeared on the same farm on which the spruces had been destroyed by a worm in 1807, or about eighty years previous.

FURTHER DATA REGARDING THE HACKMATACK OR LARCH WORM.

The following facts were gathered during the summer of 1883 in Maine and New Hampshire, and other points in New England and New York, and are here put on permanent record.

We have already stated in the Entomologist's report that the larch saw-fly (*Nematus erichsonii?*) begins to deposit its eggs at Brunswick about the 20th of June. During a journey to the Rangeley Lakes and the White Mountains this saw-fly was observed depositing its eggs, July 1, at Phillips, where it was observed to be abundant. It was also observed on the 2d at the Mountain View House, Rangeley Lake; also on the larches along the Five-Mile Carry from the Middle Dam to Umbagog. It was also observed depositing eggs in trees at Errol, N. H.; and along the route from Errol to Berlin, N. H., it was observed at work July 4, while a number of dead trees were noticed which had died from the effects of their attacks during the preceding season. We learned that they had been destructive last year in Cambridge, N. H.

Early in July these worms were also observed by us on the European larch in Lawrence, Mass., and they were abundant on the European larch on the grounds of Andrew Nichols, esq., of Danvers, Mass. July 16, the larches along the track of the Eastern Railroad from Saco to Portland were observed to be brown, having been partly defoliated by the Nematus larva; some of the trees were almost entirely stripped.

During the last week in July we went from Brunswick to Rockland, and thence along the coast to Eastport, returning to Brunswick by way of Calais and Bangor. The larch is a very common tree in the eastern portion of Maine, especially along the coast, on the islands, and in the northeastern and northern part of the State. It is comparatively rare west of the Kennebec River. It appears, then, that throughout the State

the larch was this summer partly stripped, and a small proportion of the trees were killed. The growths and forests of larch at this time assumed a peculiar light yellowish-brown appearance, as if a light fire had passed through the trees, scorching them and causing them to change their color. This singular tint was characteristic of the larches wherever we went. We noticed this appearance in the larches from Brunswick to Rockland, at Camden and Blue Hill; also on Deer Isle and adjacent islands; also at and about Southwest and Bar Harbors, and other points on Mount Desert Island and the islands eastward; also at Machiasport; but along the road from this town to Lubec the larches had suffered less than at other points in the eastern part of the State. At Saint Stephens injured larches were observed as well as at Vanceborough and the counties west of Mattawamkeag, thence to Orono and about Bangor, and between that city and Waterville.

From Mr. C. G. Atkins, United States assistant fish commissioner, we learned that the larch worm was abundant, stripping the trees, at Bucksport, and also at Cherryfield, Machias, and New Sharon.

General C. F. Walcott, of Boston, who, in September, 1883, spent several weeks at and about the Forks of the Kennebec, informs us that he noticed numerous dead hackmatacks in masses on Wood stream, which enters Wood pond, which is a part of Moose River. He did not, however, see any dead spruce in this region in clumps or masses, although his guide, an experienced boss lumberman, informed him that a great many spruce trees were dying in that region.

In the Adirondack region, from Scroon Lake to North Elba and about Mount Marcy, the larches were universally attacked by this worm, as we are informed by George Hunt, esq., of Providence, R. I., who made a journey of about 100 miles through this region in July.

REPORT UPON THE COTTON WORM IN SOUTH TEXAS IN THE SPRING AND EARLY SUMMER OF 1883.*

By Dr. E. H. ANDERSON, of Kirkwood, Miss.

KIRKWOOD, MISS., *June* 16, 1883.

SIR: I have the honor herewith to make to you the following report:

Having received on the 30th March my commission from the Department and your instructions to visit Southern Texas to investigate Aletia, especially as to its advent and all circumstances having an influence upon it, as well as to make diligent inquiry as to poisons and machinery for distributing them, I left home on the 2d April and reached Houston, Tex., on Thursday the 5th. I remained there several days, interviewing some of the more prominent citizens, especially those thought to be the best informed upon the worm question.

I soon discovered that these gentlemen were more familiar practically with the insects and machines and remedies for poisoning them than those of my latitude, and in fact were old veterans in the warfare waged by them against the Cotton Worm. Judge J. W. Johnson, now editor and proprietor of the *Houston Post*, was the first whom I chanced to meet. He, however, had not prosecuted the study of Aletia far enough to add any knowledge to its natural history, but had paid considerable attention to machines and poisons. I visited his warehouse

* In obedience to the following instructions:

DEPARTMENT OF AGRICULTURE, *March* 20, 1882.

SIR: I inclose your appointment for three months, beginning April 1. You will at once proceed to Southern Texas and institute a thorough inquiry on the following points: First. The earliest appearance of the Cotton Worm in particular sections, and all attending circumstances as to character of soil, elevation, and other surroundings, such as will throw light on the reason for such first appearance; second, the exact condition of things in Southern Texas in reference to remedies, and the machinery in vogue for applying them.

In reference to this last part of your work I want notes of experience from such practical planters as you may meet—what preferences, in other words, as to remedies applied and means of applying them their experience of the last two or three years has led to. At the close of your work you will please make a full report as to these two phases of the Cotton Worm question for that particular section.

C. V. RILEY,
Entomologist.

Dr. E. H. ANDERSON,
Kirkwood, Miss.

with him and examined his poisons and machines, in both of which he is doing an extensive business. He has a large supply of pure arsenic on hand, as well as a compound poison, manufactured by himself, of which he sells large quantities. He presented me with a large box, which I left in the hands of Dr. Ridley, near Hempstead, to be tried and reported upon, which report will be duly forwarded. Judge Johnson's machine for spraying has been described both in your Bulletin No. 3 and Agricultural Report, 1879. He claims, however, an improvement in the branch-pipes, and has arranged the machine to be worked automatically by the pitman or by the driver. His machine is certainly an admirable one, and at the reduced price of $40 is now being rapidly sold. As the season was too early for its practical application I can say nothing of its operation in the field. I had an interesting interview here with Gen. T. B. Howard. He seems to take a great interest in the discovery of Mr. L. C. White, of Jasper, Jasper County, Texas, who professes to have originated a worm-proof cotton by producing a hybrid from Jamestown weed (*Datura stramonium*). He thinks his experiments with the seed have verified Mr. White's theory. I suggested that as they belonged to two different families of plants I could not understand it, but he still thinks Mr. White has accomplished it, as the seed he gave him produced a plant like cotton, except that it had the odor of Jamestown weed and the worms would not eat it, though they eat other cotton planted side by side with it. Mr. White, I learned, had offered his seed to the Department.

I also interviewed at Houston Dr. R. T. Flewellen, to whom I had been referred as better posted on the subject of Aletia than any one there, or perhaps in Texas, as he had made the insect his study for a number of years, and had published his observations and some interesting facts. He soon convinced me that his method of investigation was careful and thorough, and that he had by experiment arrived at certain facts not stated by others, and which alone could be accounted for upon local and climatic causes. I held several interviews with him, in order to elicit all of his views and methods, and invited him to visit Fort Bend with me, which he did, and we thus had the opportunity of a free exchange of opinions and discussion of the opinions of others. As to hibernation of the chrysalis in Southern Texas, his experiments, he says, leaves no doubt. The life term of the moth he believes to be limited to twelve days, twelve in summer and six in winter, as he could never carry one beyond this. This would be due to climatic influence, admitting it to be so.

While in De Witt County I addressed him a letter requesting an answer to certain interrogatories. His reply reached me at Houston, and from it I copied his remarks on hibernation in a letter to you. He inadvertently made his experiments commence in 1868 and end in 1879, when they were made in less than one year; that is, his chrysalides were put up in the fall and were carried through the following winter and summer. I have sent this to him for revision.

I next went to Virginia Point, to visit Judge William J. Jones, a former correspondent of the Department. My interviews with him were most interesting, and were made exceedingly agreeable by his kind and affable manner. His experience with Aletia has been extensive, and has embraced a number of years, during which he has watched its coming and progress closely, and has contended with it most vigorously and persistently. He is regarded on this subject as high authority, and is the originator of an improved variety of cotton, Texas sea-island.

I questioned him closely in reference to his having observed Aletia larva descend by a web to the earth to pass through chrysalis. Although observing that as a rule the chrysalis is made on the plant, he has nevertheless seen it make the descent and pass into chrysalis on the earth. This would be an exceptional case. Although not using scientific methods in his study of Aletia, he has been a close observer, and has made himself familiar with its habits. He has used lights extensively, and believes strongly in their efficacy. He has also experimented largely with poisons, always with the result of killing the worm, and occasionally killing his cotton likewise. This led to careful experiments, conducted by himself, and to the adoption of the following formula, viz:

To 5 pounds of pure, unadulterated arsenic add 1 pound sal soda; boil in a tin vessel holding 5 gallons of water till the whole is thoroughly dissolved. If dry, one quart of this mixture to be put in 40 gallons of water well strained. This will spray one acre. If showery weather, add an additional pint. This will not cost over 3 cents an acre, and will kill in twelve to fifteen hours.

As this place has suffered from the Cotton Worm in past years, no cotton being planted there this season, it will not be amiss to mention some of its topographical features. Judge Jones's plantation is located on the extreme southeastern point of Galveston County, bounded on the east, south, and west by Galveston Bay, and extending to its margin. It forms, in fact, a peninsula, and is comparatively isolated. The soil is rich, black prairie, abounding in shells and lime. The banana, orange, oleander, and cape jessamine, and other tropical fruits and flowers grow luxuriantly. The Gulf breeze is perpetual. The temperature in winter rarely descends below 32° F. The shrubbery as well as the native larger growth and matted weeds would afford admirable shelter for hibernation. It is Judge Jones's opinion that the insect hibernates here and does not come by immigration. He believes likewise that it hibernates as chrysalis, but offered no facts in support of this theory that could be regarded as conclusive.

The next place visited by me was the plantation of Col. L. A. Ellis, at Walker's Station, Fort Bend County, situated in the Brazos bottoms, 3 miles from the river, having in cultivation 3,000 acres, 1,000 of which was in cotton. The season being a backward one, the cotton was small, and an examination furnished nothing of interest.

As the crops here are annually visited by the worm, which, in seasons favorable for its propagation, does great damage, I noted the topog-

raphy. Oyster Creek, quite a large stream, runs through this plantation from north to south, and has upon its banks a varied growth of native and luxuriant vegetation. Among the trees live-oak, cottonwood, pecan, and hackberry are the most conspicuous. From its serpentine course, forming many densely shaded curves, it would afford at many points admirable protection to insects or animals. The large size of the gin-house and corn-cribs situated near by the creek would also afford the best of winter quarters. Winter temperature and all local circumstances favor the belief that Aletia passes the winter here in some form.

From this point I went on to San Antonio, finding cotton too small for observation; but, as all climatic influences seemed favorable, determined to remain there a short time and await answers to correspondence and then go to the most promising field. While there interviewed General H. T. Bee, among others, and felt quite interested in his account of his cotton experiments in Leon and Durango, Mexico. The appearance upon cotton the first year, two hundred miles from any other cotton, and where cotton had never been planted before, leads to the presumption that the worm was indigenous and had fed upon other vegetation previously. General Bee still seems to think that it is generated by some peculiar condition of the cotton plant, on the evolution theory. All local circumstances here, the mildness of the climate during winter, the profusion of flowers furnishing nectar perpetually, and from the succulent perennial vegetation, it would appear to be the paradise of insects.

One marked feature here is what they call the sea-breeze, which is almost perpetual and only interrupted during the prevalence of a norther, which is always of short duration and scarcely worthy of the name. Without this breeze their climate would be intolerably hot.

Finding no field for observation here I went to De Witt County, where I heard the first bale of cotton always came from. Stopped a day at Cuero to see J. C. Hatton, to whom I had been referred. Found him interested on the subject of the worm and conversant with poisons. He recommends the following, viz:

No. 1. Arsenic 1 ounce; hot water to dissolve; boil until dissolved. For one barrel and one acre.

No. 2. Arsenic 1 ounce; to be dissolved in hot water and put into one barrel of water; London purple 1 pound to be added cold and well stirred in. To be used on one acre.

He also showed me several pumps, made of block tin, but none superior to those exhibited and described in Bulletin No. 3. Told me Mr. J. D. Anderson had requested me to visit him, as he thought he had the worm. On visiting Mr. Anderson's field the first object that attracted my attention was the rattoon sprouts from the stalks of the preceding year. On first examination found the eggs of Aletia much more crowded than usual, and upon footstalk as well as leaf, showing a marked preference for this cotton. Specimens of this were sent you at the time. There were occasional stalks found in the middle of the rows, while the

new crop, then (25th April) 10 inches high, and beginning to form, had single eggs only scattered here and there. The only apparent difference was that the foliage on the sprouts was more bushy. These sprouts, I was informed, appear annually, often as early as January in that locality, invariably in March and April, though I must state that I visited a field planted in cotton the previous year, about 2 miles distant, and at an elevation of 20 or 25 feet above the level of the first-named field, and exposed on all sides, where the stalks had not been plowed up, and all were dead.

This field of Mr. Anderson's is on the Guadalupe River, and strictly bottom prairie, varying from black waxy to light brown, and all extremely fertile. The field extends from the river on the west to the hills on the east, where the land breaks off into upland wooded prairie, of lime and gravelly geological formation. The hill skirting the field has at its base a luxuriant undergrowth, among which may be found many native brilliant flowers, and over which flourishes the live oak with its parasitic moss, the cotton-wood, hackberry, and others native to the clime. The country to the south along the Guadalupe is low and level, while to the southeast it presents rolling wooded prairie. Here the gulf breeze predominates, Indianola on the Gulf being but 27 miles distant, and makes the climate delightful. Here, as reported to you in detail, I found the first brood of Aletia in all its stages, except moth, though knowing the moth to be there by the freshness of the eggs, unless all of that brood had perished. Mr. Anderson informed me that previous to the appearance of the worm a number of the chrysalids had been plowed up, and that this was a matter of annual observation, and he had no doubt that the first brood of worms came from the moths that issued from the chrysalids plowed up in March and April, and that the worms often appeared as early as the 1st of April.

Learning how early the old cotton-stalks often sprouted, the early appearance of the worm, the mildness of their winters, the thermometer never falling below 19° F., the porous and loose character of their soil, and as the boll-worm does not affect their cotton, and could not be mistaken in chrysalis for Aletia, it would seem highly probable that the chrysalis would survive their short winter in that locality. Nevertheless, after the most diligent search I could not procure one, nor could I rely sufficiently upon the accuracy of their knowledge of the chrysalis to accept their statements as conclusive; and if the chrysalis did survive the winter up to the 1st of April, I was there too late, as all had emerged as moths.

I visited other places in the neighborhood, but this serves as a type for all.

Mr. Anderson had constructed under his supervision a machine for spraying, that seemed to me to possess advantages over any other that I have seen, both as to its capacity to spray a larger area in a given time and for cheapness. As he has promised to furnish me a draft I will not attempt a description. I will here copy his recipe for poisons:

Early in the season, when cotton is young and tender, one ounce of arsenic boiled in one gallon of water five minutes and then put in a barrel of cold water will destroy the worms. But in order to make it more efficient, add one-fourth pound London purple, mixed up in cold water. This will go over an acre of land when properly applied. When the cotton is older and the worms more numerous double the poison; no danger of hurting the cotton. The worms are about nine days hatching, and as heavy dews and rains will wash off the poison it must be applied every three days in hatching season. The proper time to commence poisoning is when the millers or moths are depositing their eggs. They can be seen at work after sunset and before sunrise.

I regard as important this gentleman's views, as he is a thoroughly practical man, and has the energy to execute as well as the intelligence to formulate his ideas methodically.

From this point I went to Fort Bend on the Brazos, and remained several days with Colonel Cunningham, adjoining Colonel Ellis's, the two plantations cultivating 2,000 acres of cotton. This was early in May. I inquired for the largest cotton, and on visiting the field found a few worms, specimens of which were sent to you. This was the first brood, and unsuspected until found by me. This field was located near Oyster Creek, and had upon it the decaying trunks of live oak, still covered with moss, and pecans. It was designated as mulatto land, and very rich, lying between Oyster Creek and the Brazos. The general features were such as observed upon Colonel Ellis's plantation adjoining. The mildness of winter temperature here, the many secluded spots, the abundance of native perennial flora, and the almost perpetual southern gulf breeze, as well as the great mass of stubble, rendering the soil extremely porous, would all favor the different theories entertained as to Aletia. While passing through many portions of Southern Texas, of both bald and wooded prairie, now devoted to ranches, I could not but pause to admire the profusion of wild flowers of infinite variety, intermingled with native grasses, giving an additional charm to the landscape, and furnishing food for both insect and animal. Here the moth could find a congenial winter home, if nature has endowed it with such longevity.

Next visited Hempstead. As I have reported to you from that point in detail in my correspondence, will now give a mere synopsis. Found the first brood there on the highest point in the field, where bone phosphates had been used as a fertilizer, and where cotton was then, May 14 forming. This plantation was upland wooded prairie, 3 miles from the Brazos, at an elevation of 30 or 40 feet above river, and about 70 above sea level. The soil may be called sandy loam, and quite fertile. The size of the cotton had much to do with the presence of the worm, but there were, perhaps, other agencies that aided in hastening it there. It was found near an abrupt break on the crest of the hill which had become overgrown with rank vegetation, and which sheltered a portion of the field under its lea. Here either chrysalis or moth would have been protected against the inclemency of winter. Here, likewise, all the surroundings were favorable for the preservation of insect life. It is a coincidence not without significance in my experience that the first

appearance of the worm here, as well as elsewhere, was coincident with plowing while the land was wet and temperature ruling high, thus inducing an abnormal temperature by disturbing natural capillarity. The present temperature, May 15, corresponds with the temperature of Madison County, Mississippi, in August, when worms make their appearance there. I here first tried the experiment of burning molasses placed in a pan over a lamp chimney, placing on the ground another plate containing molasses and coal-oil. First night caught two moths, second night caught ten. Would recommend in all cases, the burning of molasses, as it is my belief that the aroma is more attractive than light.

These were the first moths caught, though lights had often been previously used. Will here remark that every field I visited in Texas was infested with ants, varying from the largest to the smallest size, and differing in color. They are great pests and not only damage stands of cotton by cutting it down, as the cut-worm does, but one species sometimes excavates considerable areas with its subterranean houses, and thereby ruins both corn and cotton. They doubtless, from their predaceous habits, destroy a great many worms, and the farmers say they do.

My next visit was to Columbia, Brazoria County, where I interviewed several of the most intelligent citizens, and visited a field on the Brazos in company with Col. John Adriance, an old and highly intelligent planter. Here I found the worm on cotton near the river bank, specimens of which I sent you, though they had doubtless webbed up before reaching you. This brood was about to pass into chrysalis, as it was at Hempstead, showing it to be about contemporaneous. No new features to be observed here. The opinion prevails that the insect winters here.

I next visited Judge William J. Jones in quest of *Anomis exacta*, but had a fruitless search, as he planted no cotton this season. As the specimen sent to you by him, two years ago, was among a lot of chrysalids, gathered both on the Brazos and at his home place, and as he had never seen the larva of *exacta*, to know it distinctly from Aletia, he would have been unable to identify it.

Next proceeded to Columbus, on the Colorado. The soil here was lighter colored and more sandy than on the Brazos, in fact so loose as to be drifted by the prevailing winds. It nevertheless possesses great fertility. I found cotton here of good size and forming, and soon found the worm. Saw here the same topographical features and physical agencies as elsewhere that seem to influence the life of Aletia.

Went on to San Antonio and saw near Seguin in an upland field near the Guadalupe River some of the largest cotton I met with, but saw there nothing of interest to report.

Would have continued my observations in Southern Texas until the end of June, but as I found the insect wherever I went, as far north even as Hempstead, I determined to return to Mississippi, to watch its incoming there, as that is still an unsettled question.

My conclusion is that the southern belt of Texas, as high as 30° north latitude, offers Aletia a secure winter retreat, and that it there passes through its different stages under the influence of temperature; and although cotton is its preferred food, yet it is capable of being sustained upon other plants, selected by the instinct of the parent moth, until the incoming of cotton.

The fact has been established that it was indigenous and perennial in the Bahamas, and from my observation, and all information gathered in Texas, I think the same rule would apply there.

Finally, regarding yourself as the highest authority upon this subject, as well as all others connected with your Department, I can reconcile your last utterance upon the hibernation of Aletia, as far as facts are concerned, with the theory advocated in this report and deducible from all information gathered in my recent visit to Texas. You say "there is nothing more fully established now than that the moth hibernates principally under the shelter of rank grass in the more heavily timbered portions of the South;" and also that "you had been able to obtain the moths during every month." The only difference is a perpetuation of the cycle of transformation instead of a true hibernation in that latitude.

I have the honor to be, with sentiments of high respect,

Yours, truly,

E. H. ANDERSON.

Prof. C. V. RILEY, *Entomologist.*

EXPERIMENTAL TESTS OF MACHINERY DESIGNED FOR THE DESTRUCTION OF THE COTTON WORM.

Report by W. S. BARNARD, Ph. D.*

U. S. DEPARTMENT OF AGRICULTURE,
ENTOMOLOGICAL DIVISION,
Washington, D. C., August 15, 1883.

SIR: Under your direction I have prepared and hereby submit the following report on the experimental tests made during the last three weeks near Selma, Ala.

Respectfully,

W. S. BARNARD, *Assistant.*

C. V. RILEY, *Entomologist.*

REPORT.

The Cotton Worm machine described in the annual report for 1881–82, and now subjected to field tests, is shown to be suited only for cotton so planted that the rows are spaced apart very equally, since it lacks adaptability to the usual great differences of interspaces between the rows. Unfortunately, nothing very closely approaching ideal straightness of rows or equality of width between them can be detected in the South, even in such fields as are said to be "planted perfectly true."

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* Letter of instruction.

DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
July 14, 1883.

SIR: You will proceed to Selma, Ala., on the 18th of this month to carry out in detail the verbal instructions which I have given you. These are, chiefly, to take with you or send all the machinery necessary to put together and operate the spraying machine illustrated on Plate IX of our last annual report. You will test this machine thoroughly, in order to settle by experience the numerous points that have not yet had practical field demonstration. Thus, the most satisfactory form of nozzle, whether for London purple, Paris green, or kerosene emulsion, the number of rows it is found best to spray at once, the relative effects of finer or coarser sprays, and particularly the effect of petroleum, etc., etc. Be particular to ascertain the actual cost and actual area covered by a given amount of liquid. You will spend no time in testing other devices or modes of poisoning.

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Respectfully,

C. V. RILEY,
Entomologist.

Prof. W. S. BARNARD,
Assistant, Entomological Division.

In the more evenly disposed cotton, stiff fork apparatus, made light and shorter, to supply only four rows at each drive, and hung loosely upon hooks instead of eyes, without the ratchet lever elevator, and capable of being easily slid by hand to the left or right, as infringement on row crooks from time to time required, proved susceptible of use with due watchfulness; but the eight-row machine was too heavy to be thus shifted by hand, and being stiff-backed with rigid descending pipes, no eight consecutive rows could be found regular enough to be callipered for much distance by this device. The inflexibility also prevented conformability of the apparatus to inequalities of the ground, an elevation straining hard on one descending pipe, lifting the others from the ground, etc., and the light, flexile, jointed nozzle-arms, being borne upon severely by the stiff pipe system, soon became impaired, whereas they had formerly and have since worked well on the yielding stem-pipes of the adjustable machines which were tested at the time of the Atlanta exposition, as well as in these last experiments. For underspraying, this old-fashioned, stiff, cross-pipe system is shown to be wrong, as originally foreseen, unless some power can be brought to bear to enforce a system of greater straightness and equality in planting cotton. A considerable amount of the irregularity in rows has been attributed to the "constitutional perversity and crookedness of the nigger," appearing from the bad execution of his instructions. But even if this could be corrected it is not the matter of vital importance, for the planter himself, as well as the field-hand, is guided by a natural principle which will always control and stand against any contrary theoretical or mechanical rule. According to "the strength of the ground," the size of plant it will produce, will the rows run wider or narrower in any particular "cut" or part of a "cut." This accounts for the diverging and meandering rows, for the many "cuts" of a plantation differing among each other in their row-widths as observed everywhere.

As to conveyances for underspraying apparatuses, it was found not desirable to use a wagon or cart of ordinary width (5 feet) in cotton only 3 feet wide or less, because of the much injury done to the plants by the wheels. Most of the cotton in the Carolinas, Georgia, Tennessee, Alabama, and Mississippi comes within these dimensions; hence a shorter special axle for the cart or wagon wheels should generally be employed in any conveyance for the apparatus. But where severely threatened by worms the ordinary wagon or cart will do less damage than the pest in any kind of cotton; and it is on this account that wagons are already used to a considerable extent for transporting poison and broadcast spraying devices in all kinds of fields. Mr. A. T. Jones, near Selma, uses four mules on his heavy spraying machine. But ordinarily the common plantation cart will be found the most suitable vehicle. This or the lumber wagon will straddle rows 4 feet apart or over without injury to the plants except in turning, and that is surprisingly small, being least with the cart. With shafts

placed in the usual position the mule must travel on a row to have the two wheels straddle it properly, and this not practical. I obviated the objection by a pair of rough shafts set to one side, one shaft coming from the center of the cart and the other standing outside of the wheel; thus the mule is held nearly in front of one wheel and midway between a pair of rows. In practice it is shown that the slight side-draft caused by this arrangement amounts to almost nothing. And it should be remembered that it is common in the North to use side shafts on sleighs, buggies, &c. The apparatus is easily pulled by one mule, which should travel preferably in front of the right wheel.

The personal labor required is such that the pumper may also drive and keep an eye on the machine behind. It is most convenient when the stirrer, pump, and barrel are placed near the left side of the cart with the lever or pump-handle standing crosswise. The operator then only looks to the right and the left instead of having to look backward. The mule, accustomed to working in cotton, follows between the rows as a rule without being guided, and the pumper is free to turn him at the ends. In this manner one man can use the apparatus alone without working any harder than he should. Still, it is generally preferable to have a boy attendant to assist at times, and where a larger pump with a very wide system of pipes to supply a large number of rows is engaged it will be well to have two men to take turns at pumping in cases where a pump motor is not provided. With such labor, the adjustable under-spraying machines which I have devised and shall notice below were operated, the best hand being a mulatto who worked for fifty cents a day, which is a common price for cotton-field hands. Thus the labor cost is small, and one or two men with a machine can do much more and better spraying than a large gang does by ordinary methods.

The rapidity depends altogether on the width of the pipe-system, or number and width of rows supplied, or the size of the cotton, of the nozzle-discharges and of the pump, on the velocity or pressure applied, and on the speed of the mule. It may vary with any one of these details. I had only one pump, this rather small, and could not try the effects of different sizes. There was not much diversity in the cotton and it was below medium size. At Selma, I labored under difficulties from bad workmanship, from lack of available mechanics for constructing the devices, on which account there were bad joints in the apparatuses, which leaked some, and which would loosen and at times come apart when high pressure was applied, thus causing stoppages in the work. Under the circumstances the question of time and scope could not be very satisfactorily tested; but as to the very fine small sprays for small cotton the following conclusions result from this experience:

Taking nearly average sized cotton, and the parts of the apparatus of medium capacity, an acre and a half was poisoned in one-half an hour, 24 feet wide being poisoned at a single drive, and the rows were quite short. Twice this rapidity can be attained.

The quantity of liquid and poison used also depends on the various conditions stated as determining the rapidity. The amount of liquid to the acre, as near as could be estimated under the circumstances, ranged from 10 to 40 gallons, according to the size of the spray-discharge and of the cotton. The quantity of poison is in direct proportion thereto, being one-eighth to one-half a pound of London purple, or one-fourth to four-fourths of a pound of Paris green to the acre.

The stirrer-pump device is a most perfect thing for the purpose and gave the greatest satisfaction. This contrivance is described and illustrated in the annual report for 1881–'82 (pl. ix, pp. 159–161). The pump has heavy metallic valves, and its piston-head has no soft packing, so there is nothing about it that can get out of order. Yarn packing is used in the stuffing-box at its top. Being double acting it throws a strong and constant stream. Only one trunnion-eye need be moved, and a single iron wedge, instead of two, is sufficient for setting it. The wedge has on its head a catch whereby it is easily pryed out, and an eye by which it is chained fast to prevent losing it. In place of the wooden stirrer bar formerly employed I have made an iron one having a spring at the middle to clamp snugly in the eye at the bottom of the pump. This will not weaken with age or break. The cord or chain for pulling out the bar is not essential, as by having the end bung-hole of two inches diameter a pair of tongs or pinchers can be inserted to take hold of the end of the stirrer and extract it. The main hose or pipe has a screw union, by which it is easily separable from the pump.

The descending pipes between the rows should have flexion and torsion in their joints or segments or hangings. The ground beneath the cotton-rows is highly ridged, and the mid-furrow between each pair of rows is deep. The ground thus formed operates upon the lower parts of each descending pipe or its appurtenances, when suitably shaped, so as automatically to guide the pipe and its nozzles between the rows, and to follow any crooks therein even when the conveyance is not driven in conformity with such irregularities. This automatical adjusting is allowed to a large extent even when the top of the descending pipe is firmly or non-adjustably attached, provided that the descending pipe be flexile in some part of its course. This was shown in the earlier flexile forked machines which were tested for this Department near the Atlanta exposition. For the object in question the descending pipe may be flexile throughout, but it is more commonly preferable to construct this pipe of stiff segments having one or two flexile joints, or very short hose segments; one at its top, and another at about two-thirds or one-half of the way downward therefrom. It is also generally best to make these flexile segments or joints of three-ply or two-ply hose, and only of such length as to allow them to bend like knee-joints, and to suffer a semi-rotation or semi-torsion. This construction prevents the trailing-fork or other end part from getting turned upside down, or from remaining in wrong

attitude after dragging among or over the plants in turning, and it always tends to spring or throw the nozzles back to such positions that they deliver a properly-directed spray into the plants. Where torsion without bending is desired in these flexile places a rod extending through the interior may be employed somewhat as described for cross-pipes and nozzle-arms in the special report of the United States Entomological Commission that has been prepared. The arrangements and constructions referred to have been carefully tested this season to corroborate the results of previous experience. The principle involved is simple and practical in its operation, having been tested at Atlanta, and again this year at Selma, Ala.

The flexile nozzle-arms of the Y-shaped trailing forks which were originally designed with flexile stems worked satisfactorily thus attached; but when these fork-arms were tested on a stiffly hung pipe, the spring-rod inside soon proved too weak. The strong pendant T-forks with curved or sloping side-arms made stiff proximally, and having 3-ply hose for their distal half or two-thirds, stood severe usage by all methods, since they were made of stronger tubing and had much stouter spring-rods within. The spring-rod in each arm had its distal end soldered in a short piece of tube abutting against the stem of the nozzle. Forks of whatever construction will be guided more by the ridges if the arms extend in a somewhat upward direction before becoming horizontal at the ends beneath the plants, as the median part of the fork can then sink into the mid-furrow and be guided by its sides. Probably nothing better than the pendant Y-forks and T-forks can be devised for spraying upward through the center of the plant. An additional pair of short arms or of nozzles may be used with advantage to discharge from near the median line in divergent direction upward through the tops of the plants. The simplest plan is to join these or the simple eddy chambers directly to the stem-pipe or its extension, low down. Such nozzles may be attached side by side, or in what I call a tandem gang. This is a series of short tubes coupled end to end, each bearing an eddy-chamber discharge. These may be rotated on their axes and so are adjustable to different angles. Those who prefer to underspray the top of the plant and care less for its base will find the tandem arrangement by itself the best device for that purpose for throwing from the ground, though the forks answer as well when elevated, and may also be used beneath the base.

The eddy-chamber nozzles seem the best sprayers available for applying the poison. These nozzles have been tested this season with the discharge-hole of various sizes, from one-sixty-fourth to one-eighth of an inch diameter. The smaller orifices give the finest sprays conceivable. Indeed, with high pressure, the spray vanishes into vapor and steam which does not fall, but rises to seek the clouds. From this the damp particles of poison powder must separate and fall. But with ordinary pressure too fine a spray is not attained.

With the fine strainer on the suction end of the pump, clogging materials in the water are prevented from entering the pipe system or the nozzles. Additional smaller gauze strainers were attached to the ends of the metal tubes in one set of pipes. They keep out dirt, etc., when the pipes are separated, but may not prove of importance. The proper method is to have a completely closed system, with folding joints that never need to be separated, so the whole can be folded into a small compact package for transportation by rail or to the field. Such a system has given great satisfaction by its convenience, as well as by allowing no obstacles to enter the nozzles. In spite of the most perfect precautions clogging will occur at the outset or before high pressure is attained, chiefly from the scales of iron separating from the interior of the pipe as loosened by rusting and jarring. With the finest nozzles (one sixty-fourth inch discharge) these seem to cause no more difficulty than with a standard beveled one-sixteenth inch discharge. The nozzle faces may be removed to let out any obstacles which with low pressure are apt to clog the outlet and stop the internal rotation. But a high pressure should always be used, and when this is once up the outlet may be pricked with a pin, and it will discharge with an almost explosive force, instantly starting an inconceivably rapid internal rotation, which, while sustained with due pressure, will by its centrifugal action prevent any particle from again finding the center of rotation from which the discharge takes place. This is especially true of the smallest nozzles, having an outlet just large enough to admit the insertion of a pin. As previously set forth, the inner edge of the outlet should generally be square or sharp. In the eddy chamber a great hydraulic pressure is generated, so great that by thumb pressure the discharge cannot be stopped. The power therein accumulated under high pressure is sufficient to cut through and disintegrate any obstructing particles or fragments, except those of the hardest kind, which are so heavy as to fly off from the center by their weight and momentum when the velocity of rotation is once up or quickly starts.

The top adjustments of the descending pipes are very important. These tops may be variously hung, combined, or constructed. A knowledge of the irregularities of ordinary cotton fields, such as appear chiefly in crooks of the rows and in variations of width between them, prevents the idea of a stiff, unadjustable attachment of the tops of the pipes, which must travel between and more or less against the rows. Conformity to all inequalities of the ground, its numerous ups and downs, its dead furrows, ditches, stones, and stumps, should likewise be attained. It must also be evident that a large, stiff apparatus is difficult to haul about, as it cannot be taken entire through gates except with much labor. Of course it is possible to disjoint the parts beforehand, and then screw them together tight afterwards when the field is reached. This, however, is hardly practicable. In fact the separating and joining of stiff metal joints by field hands is a failure. Plumber's tools are neces-

sary for this purpose. The field laborer of the South screws up the joint too tight, too loose, or in such form as to spoil the screw-threads. Again, the joints become rusted together and a vise must be engaged. The stiff system also requires that very heavy pipe be used, as the leverage on long pipe arms enables them to suffer great strain, to become broken off easily at the end where the thread for the joint is cut, whereas with flexile joints no leverage power but only *tensile* strain can be brought to bear. In the latter case very light tubing can be employed with economy in material, cost, labor, and salvage of cotton. Moreover, only by such light flexile apparatus can any considerable number of rows be treated at once from beneath. These facts have been substantiated by tests of stiff and of flexile apparatus this season more fully than they were by the Atlanta tests, in which one light machine undersprayed eighteen rows of cotton, a strip twenty yards wide, at a single drive. The tests this year have been not only of stiff connections, but also of the constructions whereby adjustability of the descending pipes is effected automatically and by hand. These have already been noticed above or in the previous reports in so far as they pertain to the stem or body of the pipe or its distal appendages; hence, next in order may be considered more specifically and in natural sequence the construction and arrangements of the tops of these pipes as planned and tested by me:

I. The stiff hanging tubes have been tried, as already set forth, in firm union with a stiff back-pipe or cross-pipe such as appears in many of the patented sprayers, as Johnson's, Daughtrey's, etc., while sufficient objections to this arrangement for underspraying have already been presented. It is the first construction which naturally suggests itself to any plumber or other mechanic, but presents no special adaptation for the purpose, as has been shown this season and previously.

II. The extremest opposite construction to the foregoing is attained by having radiating flexile tubes from the main to the descending pipes, instead of a straight and stiff cross-pipe. By this arrangement the hanging pipes are swung apart or nearer together independently, and set on a cross-bar or on diverging bars, at spaces to suit rows having different courses or widths.

By way of variation the tubes may radiate only for a part of the distance, and for a space run close beside each other along a supporting bar before reaching the descending parts. The parts upon the support are preferably of metal, and slide readily in peculiarly locked hooks, as simple, easily separable attachments, specially devised for this purpose. Where the descending parts have flexibility to some extent they may drag in the cotton in turning, as stated above. It is shown that they thus do no noteworthy harm to the plants; also that they themselves do not suffer injury. This flexile construction is simple, and generally preferable in combination with the flexile connectives between their tops. But should any prefer that the hanging parts be elevated above the plants in turning, this is easily done. For such purpose, and to shorten the lever-

age in lifting, the descending part should preferably have a flexile joint just below midway, to bend like a knee when the lift is made. The upper half of the descending pipe is rigidly continuous with the stiff parallel part, forming therewith a bent angle, while the proximal end of the parallel part is turned backward as a hollow tubular crank, having its handle-end communicating with one of the radiating or slack hose pipes, which allow the stiff parts to be shifted laterally. By swinging the backward crank-shaped part of the pipe over to a forward position, into a catch, the hanging parts of the pipe are swung upward above the plants and sustained there. This season two, three, and four of these crank-ended pipes were tried, combined with the same bar. When the horizontal part of such a pipe is short or not too heavy it will be shifted laterally automatically by the trailing part by the method already noticed; but where the pipe is too heavy or rough to slide easily the hand of the pumper must occasionally be used upon the proximal or crank end to shove the pipe into such position as will suitably adjust the nozzles to the rows.

In the divergent arrangements thus indicated the shifting or lateral adjustability is permitted by opening or shutting the angles between the diverging tubes, and this is, in its operation, in some sense, analogous to taking out and letting out slack in the connecting parts between the nozzles. By a surplus amount of inflection or slack, by joint or other flexibility, in a tube or tubes connecting the tops of any two neighboring pipes, whether right, left, or mesial, in a system, the two can be separated, approximated, or independently adjusted to the extent desired. By this method the stiff pieces sliding on the bar and supporting the pipe-tops can be short, light, and arranged somewhat end to end, joined in tandem order, with intermediate flexile crooks that may be extended or shortened as operated by the automatic action of the trailing branch. These tandem gangs of light, sliding segments for supporting or supplying the tops of the pipes, have stood a satisfactory test in the cotton this season.

Such parts may also be arranged on bars having a slope backward or downward, as on the A-frames, or other kinds of frames, or they can be set in a somewhat zigzag manner on a cross-bar. This use of a slope gives certain advantages, and characterizes some varieties of apparatus closely related to that just noticed. In these, the pulling of the downward pipe, by its gravitation or friction, causes its top piece, which has an inclination to slide on the slope, to travel in a diagonal direction along on the support and across the rows; but working in opposition thereto is a pull-line or cord having one end on a winder near the hand of the pumper. Letting out the line allows the pipe to travel farther along the slope, and winding it up draws the pipe in the opposite direction. Thus any pipe at a distance can be easily shifted and set at a point to suit by letting out or drawing the line. This principle I have executed in three ways: In the first, the supply tube

supports the hung-pipe and slides in eyes situated diagonally with reference to the hung-pipe. In the second, the pipe-top is supplied by a flexile piece of hose, and is supported by a long slide-rod on one or two of its sides, and inserted through loose eyes placed diagonally from the course of traction, as in the foregoing case. In the third instance, the top is similarly supplied by a hose, but is hung by a peculiar locked hook, eye, or loop which glides loosely on a stiffly-set diagonal bar. The simple wooden A-frame answers, and a series of small sloping metal bars of gas-pipe were arranged on a wooden cross-bar. This device worked well. Many kinds of winders would apply, but a simple plan is to wind the small rope or cord around a pair of large eye-screws placed 3 inches apart. The set line can be attached at any point along the sliding parts. Behind the proximal end of the range, through which any pipe-top is to be allowed to slide, the line may pass through a large screw-eye and thence to an extension of the pipe-top above the axis on which it is hung. Then the pipe may be drawn to this place, and by an extra pull its top will be brought down to the eye and the lower parts of the pipe will be tilted upward above the plants for turning, when this feature is desired.

Concerning the use of kerosene upon cotton, the following should be stated: About 10 gallons were applied, half undiluted and half in emulsion variously diluted. The undiluted petroleum destroyed about 10 per cent. of the foliage sprayed by it. The undiluted milk-kerosene emulsion ruined only about 2 per cent., and this diluted injures less and less according to the attenuation, but all treated was injured to at least a slight extent. The sprays were hardly satisfactory, as the tubing would not permit the high pressure necessary for a very fine mist, and the indications are that with the finest spray the strong kerosene and its slightly diluted preparations may possibly yet become used, in proper hands with great caution, upon the crop, but additional experimental tests are needed.

The apparatus taken, with the different machines constructed at Selma and overcoming the objections herein set forth, have been shipped to the Department.

The leading conclusions from the experiments upon the special points in my instructions may be extracted from the above and briefly summarized as follows:

At Selma, I operated the machine taken from the Department and tested the points in question, so far as circumstances permitted. The distinctive feature of the machine, its stiff supporting pipes, unfitted it for the work to be accomplished. As fields could not be found having rows practically of the same regular width as the spaces at which the downward pipes were held stiff by their supporting pipe, that permitted no independent lateral adjustment of the tops of the hanging pipes with reference to each other or to the rows having different or varying widths, this vital impediment at the outset frustrated its use and the obtain-

ment of results dependent thereon. The tests showed that with a pipe-system, without lateral adjustability at the top, very few rows, usually not more than four, can be treated at once. In this small form the whole pipe system can occasionally be moved laterally by hand as the row irregularities require it.

The forks were operated dragging upon the ground, and also set at different heights. The ratchet for vertical adjustment subserved this purpose satisfactorily. Where it is desired to spray the base and interior of the plants from beneath, the nozzle arms must necessarily be carried near or on the ground, and with medium to small cotton this method also sprays the tops sufficiently well, but if the growth be heavy and dense it proves better to set the forks higher for more thoroughly poisoning the tops.

The stirrer pump worked admirably; but a larger pump of the same kind was necessary to treat a greater number of rows, to ascertain how large a number it is possible or advisable to spray at a time. While the large pump was being constructed and shipped the time limited by my orders expired.

Four rows may be set as the number it is most practical to treat at a time with the kind of machine in question.

The springs of the fork-arms should be larger and have a longer bend than in the samples taken, since the unyielding attachment of the stem-pipes to the stiff supporting pipe above throws on the springs much greater strain than occurs in the machines having descending parts hung to operate independently of each other.

Until my time had expired worms were not abundant enough to study the effects on them of the coarser and finer sprays applied, but the coarser spray was more injurious to the foliage with poisons, and still more so with petroleum.

The standard form of eddy-chamber nozzle was used with discharges of different sizes. The smallest discharge holes, of $\frac{1}{64}$ to $\frac{1}{16}$ of an inch diameter, with very high pressure, gave the most satisfactory results.

The "actual cost, and the actual area covered by a given amount of liquid," vary greatly with the width between the rows, the sizes of the sprays and of the plants, with the number of nozzles, with the amount of pressure applied and the volume capacity of the pump, the velocity at which the machine is drawn, etc. On account of the complexity of the question, and especially because of leakage from imperfect pipe-joints and for want of other and larger apparatus, the question could not be solved with any exactness.

ON SOME OF THE NORTH AMERICAN COSSIDÆ, WITH FACTS IN THE LIFE HISTORY OF COSSUS CENTERENSIS Lintner.

By James S. Bailey, A. M., M. D., Albany, N. Y.

Cossus centerensis (Plate I) was discovered by Dr. Theodore P. Bailey in 1877. For many years previous I had observed that many trees of the *Populus tremuloides* had perished from some cause then unknown. The central shoots of other trees of the same species were dead, and it would only require a few years to finish their destruction. Perforations were found in the trunks of these trees, some of recent date and some overgrown with bark, leaving the cicatrices plainly visible.

In July, 1876, a brittle pupa-case of the Cossus was found projecting from one of the openings, which gave the first clue to the nature of the borer and destroyer of the timber.

On the 10th of June, 1877, a fresh pupa-case was discovered, and on the 14th of the same month the first Cossus was captured, resting upon the same tree trunk. Every season since this capture the Cossus has been taken, but in some years in greater numbers than others.

The Cossus usually comes forth between the setting and rising of the sun, and when the trees are visited daily the protruding pupa-cases left behind by the escaped imagines informs the collector how many of the insects he may expect to find.

Their color similates so closely the color of the bark of the trees that it requires good eyes and very close observation to find the moths. One unaccustomed to collect them might view an infested tree for a long time and not find a Cossus, when several would be discovered by an expert. An uneven protuberance on the bark, or the short stump left of a decayed broken limb are favorite resting places for the insect.

The moth at first is rather sluggish, and can be easily captured. After it has been abroad for some days it is wild and more or less mutilated. This Cossus is not attracted by sugar, as might be expected from its aborted tongue.* The moth seems to belong to the genus *Cossus* Fabr., and not to be congeneric with *Xystus robiniæ*. The head is short, eyes naked, labial palpi small, appressed, scaled. The thorax is thickly scaled, the scales gathered into a ridge behind, and is squarer

* The writer is desirous of producing all the known facts in reference to this insect in this paper; therefore the descriptive parts which have been published before are reproduced.

in front than in *Xystus*, not so elongate or so elevated dorsally. The male antennæ are bipectinate; the lamellæ rather short and ciliate. The female antennæ are serrated. It is allied to the European *Cossus terebra* F., but is a larger insect. It differs from *C. querciperda* Fitch by the absence of any yellow on the male hind wing, and by its darker color and closer reticulations.

In color this species is black and gray. The edges of the thorax and collar are shaded with gray, more noticeable on some specimens than others. The primaries are covered with black reticulations, which are not always identical in their minor details in different specimens, nor sometimes on both wings in the same specimen. Beyond the cell there is a transverse continuous line, broader than the rest, and outwardly bent over median nervules. The brown color is blackish over nearly two-thirds of the primaries from the base, and outwardly gray; hind wings rounded in both sexes, with blackish hairs at base, pale and subpellucid, with short gray fringe, before which there is a narrow blackish edging. The abdomen is blackish. The males are smaller than the females. The smallest male expands about 40^{mm}, the largest female over 60^{mm} (see Plate I, Figs. 10, 11, and 12). While thus far the Centre (N. Y.) locality has proved to be the chief home of this Cossus, it will undoubtedly be found elsewhere wherever the *Populus tremuloides* is found. Several pupa-cases of this species have been found in the corporate limits of Albany. Usually trees of less than 1 foot in diameter are attacked, although in one instance a pupa-case was found in a tree measuring 16 inches in diameter.

It is a very different matter to observe the changes of insect life from the eggs to the imago when feeding upon the foliage of vegetation than where the larvæ have bored deep into a tree trunk and feed upon the ligneous fiber and its circulating fluids. To obtain this information it has been necessary several times each year to cut down trees bearing indications of its ravages, and to dissect them into fragments the size of kindling-wood. The months of October, April, and June were selected as suitable times for such investigations. October 14 we visited a tree for the purpose of obtaining caterpillars, and from a limb 4 feet in length six caterpillars were taken, two of which were occupying cells as seen in the engraving.

April 2 we cut from a tree a limb 3 feet in length, and in it we found seventeen caterpillars of three distinct sizes, indicating a growth for each year. The larger ones were not fully grown. All of them were actively passing through their tunnels in the wet wood, through which the sap was freely flowing. Not any of the caterpillars were occupying pupa-cells at this time. June 12, 1881, we again visited a tree when the insects were emerging. The tree selected was far advanced in decay, from the effects of the tunneling of the larvæ; only about 4 feet of the trunk was alive, with a few lateral branches in foliage, scarcely enough to support its respiration. In the trunk were found fresh pupa-cases, pupæ, and

caterpillars. Again three crops of larvæ were found; the larger ones were inactive and lying in the sap-wood, with their heads close to the bark which was gnawed nearly through to the outer surface. These caterpillars had evidently taken their last position preparatory to their final transformation into pupæ. Pupæ were also found occupying the same position, and when the bark was removed were visible.

The larva taken October 14 from its burrows is 45^{mm} in length, of a pale flesh color. It is a little broader anteriorly. The prothoracic segment is blackish brown above, the dark color edged with a dirty orange shading. The head is mahogany brown, shining, slightly roughened. The mandibles are black, with strong teeth. The surface of the head gives rise here and there to single scattered hairs. The antennæ are three-jointed; the second joint gives rise to a single long hair. The seventh eighth, ninth, and tenth abdominal segments are provided with false feet. The segments are marked with a lateral row of brown dots above the reddish stigmata, and there is a row of similar dots, two to a segment, on each side of the dorsal line. These dots give rise to single pale hairs. The larva moves with freedom either backward or forward. The burrows which it excavates are about 15^{mm} in width and terminate in the pupating cell, which is about 40^{mm} in length, smooth; the extremity towards the opening is closed by a wad of finer and then coarser filings of the wood. The coarser splinters are not detached entirely from the wood, but are split up by the larvæ all around the top of the cell, and project like bristles, appearing somewhat as those wooden toy trees which are made for children, and which are formed by shaving down the wood and leaving the shavings adhering by one end. These splinters make a firm wad. Against them are piled a quantity of finer chips or thin filings, which are loose but pressed together.

The cell (Plate 1, Fig. 7) is about 40^{mm} from the outer bark of the tree, and the chrysalis (Figs. 8 and 9) makes its way to the air through the burrow, by means of its teeth on the segments and the spinose process on the front, by which it forces itself, by stretching and contracting the abdomen, through the wood scrapings which close the cell, until it comes to the end. We have noticed a fine thread of silk proceeding from the spinneret of the larva, although in the cocoon we have found no silk whatever. The cocoon or pupa-cell seems to have been formed by wedging first coarser and then finer strips of the wood together, and seems to be merely a more carefully and smoothly finished enlargement of the original burrow.

A specimen of the pupa which I have examined is about 30^{mm} in length, narrow, brownish black, shining rugose. The clypeus presents a strong, broad, spinous process, supported at base by lateral projections. On the under side it descends into a wide sulcation terminating in a broad projection. The capital appendages are visible, and here and there arise isolated hairs as in the previous stage. The abdominal segments are provided with teeth over the dorsum, decreasing in size to the stigmatal

line. The anal segment is provided with two unequal-sized terminal teeth on each side of the vent. (Plate I, Figs. 8 and 9.)

The chrysalides vary much in size, and some of them are infested with an ichneumon fly, which preys on the caterpillar. A pupa was observed endeavoring to make its way to the surface of the bark, but seemingly unable to extricate itself, when assistance was rendered by enlarging the orifice. It was laid in a paper box for hatching. A few days afterwards many minute ichneumons were observed resting upon the wall near the box. On examination they were found to be escaping through minute holes in the pupa, which would barely admit a No. 3 entomological pin. Fifteen of these perforations were counted in this pupa. I presume that the larva of the Cossus is pursued in its burrows by the parent parasite. If so it is curious that the Cossus pupa is not killed by the parasites until it has worked itself up to the mouth of the tunnel, thus allowing the ichneumon flies to escape outside.

When ready to emerge, the pupa, by means of stout cusps on its abdominal segments, works itself to the end of the opening, and with its pointed head-case the thin portion of bark which has been left by the caterpillar's instinct is severed and removed. It pushes itself through the opening as far as the base of the abdomen, by a sort of rotary motion, which acts in its mode of cutting like a carpenter's center-bit. The thoracic end of the pupa after exposure a short time to the air becomes dry and splits, and the moth escapes, climbing up the bark of the tree, shaking out its wings, until developed. After the moth has escaped the empty pupa-case may still be seen protruding from the entrance of the tunnel. It is not true that *Cossus centerensis* prefers dead wood to burrow in. It is a fact that it is most frequently found in partially decayed trees, for after the larvæ obtain a lodgment by its perforations in diverse directions through the heart and alburnum, admitting air and water, it causes irreparable decay. There are three species of poplar found in the vicinity of Centre,* viz, *grandidentata*, *dilatola*, and *tremuloides*, but as yet *C. centerensis* has only been found in the *Populus tremuloides*.

It is stated by Harris that *C. ligniperda* deposits her eggs on the bark near the root of the tree, which I believe is the habit of most of the borers. It would seem from the following that it is not the invariable mode. In splitting open a tree trunk on June 12 a Cossus was observed to fly from the cleft, which on being captured proved to be a female. It was supposed she had taken possession of a tunnel for the purpose of depositing her eggs. The loose *débris* from the excavations was gathered together, an examination of which revealed Cossus eggs. (Plate I, Figs 1 and 2.) The female was confined in a box; the next morning she had deposited fifty-two eggs; some of them were attached to the sides and others on the bottom of the box. Some of the eggs

*Now called Karner.

were deposited singly and some in confused heaps, and were attached to each other and to the box with a viscid substance.

Another female was captured June 20, and in forty-eight hours after being pinned she had deposited sixty eggs, which varied somewhat in color from the former.

The Cossus after being pinned is very restive, especially while depositing her ova and by the constant motion of the oviposter in endeavoring to extrude the ova. The loose abdominal scales are removed and attached to the eggs by the moist viscid fluid with which they are covered, and which often gives them the appearance of being clothed with scales. A few of the ova collected this season have this appearance, but a strong lens exposes the true condition. *C. centerensis* is not so prolific as some of the other species of *Cossidæ*. *C. robiniæ* Peck and *C. querciperda* Fitch have been known to extrude upwards of three hundred ova. In European species over one thousand ova have been found on dissection. The ruin of whole forests of timber in which these insects revel is doubtless prevented by the destruction of the eggs by ants and birds, the size of the eggs being sufficient to form a tempting morsel. In a state of nature the female Cossus deposits a small number of her ova upon each tree which she visits until her supply is exhausted.

This season the enlarged perforations through the bark show unmistakable evidence that the trees had been recently visited by woodpeckers, which could find little difficulty in procuring an abundance of full-grown larvæ.

C. centerensis is found throughout the region known as the pine barrens, which cover an area of perhaps 12 square miles between Albany and Schenectady. The soil of this region seems especially well adapted to the growth of the timber which it supports.

At the present time no correct observations have been made in reference to the molts of the caterpillars, but information on this subject will soon be obtained from Mr. A. H. Mundt, of Illinois, who has had opportunities of observing, up to the fourth molt, the caterpillars of *C. robiniæ*, which are found in the willows and poplars in his vicinity.

Cossus centerensis appears every year, and from observations and from numerous examinations of the trees by actual sections during the three months of the year enumerated, I am convinced that the caterpillars are not fully matured until the end of the third year, when they arrive at their perfect or winged state. The pupa state is comparatively short, lasting less than a month before the moth appears. From figures 3, 4, and 5 of Plate I we see representations of caterpillars found October 14, which establish the fact beyond dispute, through observations extending over many years, that it requires three full years for the caterpillar to arrive at maturity.

Cossus angrezi Bailey.

(Plate II, Fig. 6.)

We repeat the original description of this species, given in Papilio for June, 1882 (Vol. II, No. 6, p. 93):

Cossus angrezi. n. s. ♀. Head somewhat narrow on the vertex. Collar and head yellowish gray, thorax black; the edges of the tegulæ shaded with yellowish gray. Fore wings with a nearly white ground, shaded with black, and with black reticulations. Hind wings yellowish gray, mottled with blackish outwardly. The fore wings have the costal edge pale, marked with black; the black shading obtains on costa at apical third, and over the whole wing at terminal third, extending obliquely downwards and inwards; there are a series of interspacial longitudinal black streaks before the margin, more or less defined. Fringes whitish, dotted with black opposite the ends of the veins, which latter conversely are whitish. Thorax shaded with yellowish gray behind. Abdomen dark gray. Beneath the wings repeat the markings very distinctly, owing to the strong contrast of the pale ground color with the black markings. Expanse, 82 mm. 1 ♀. Wells, Elko Co., Nevada. From the late Mrs. Caroline Chase. Type, coll. James S. Bailey.

This I believe is a true *Cossus*, although the ♂ is not known to me. The shape of the wing is as in *centerensis*. The structure is that of *Cossus*, and not of *Prionoxystus*. The thorax is subquadrate, the vestiture short and thick. The interspacial black dashes along the primaries subterminally distinguish it specifically. The pre-apical transverse black streak or line resembles that of *C. centerensis*. The hind wings are faintly reticulated. The ground color is a yellowish white. The black blotches on fore wings of *robiniæ* are here wanting, while there is a diffuse discal shade blotch, another above and beyond it on costa, and the wing shows a wide, soft, blackish shading, obliquely edged inwardly and covering the outer portions of the wing. Except the antennæ my type is perfect. Beneath it is strongly marked, and reminds one of *C. robiniæ* Peck, but the shape of the wing is not like that species. The thorax is black above, not gray with black stripe on tegulæ, and the collar is discolorous, pale yellowish gray. This species ought to be recognizable. The shape of the thorax is like *Cossus*, as is the vestiture, so that I am not prepared to find that the male has the peculiarities of *C. robiniæ* and *querciperda* Fitch. I hope Western collectors will solve the question. But I cannot regard *angrezi* as having anything to do with the question of a Western representative of *robiniæ*. From Herrich-Schaefer's figure, and what has been published, I believe that *robiniæ* is found across the continent.

Prionoxystus robiniæ Peck.

I have a female with extended ovipositor. We have probably only one species, reaching from California to the East, and this is phytophagic, feeding on the oak, willow, as well as the locust and other trees. No difference by which these forms can be separated is appreciable. The female is redescribed as *crepara* by Dr. Harris. The insect was common in 1882 in different localities in New York State.

STRUCTURE.—The female antennæ are pectinate. The terminal segment of the abdomen narrows and becomes elongated and cylindrical towards its extremity. The male secondaries are half the size of the female's and obliquely and sqarely cut off along external margin, being also discolorous and of a bright yellow. The thorax is long and narrowed, elevated in front of the fore wings. The head is longer and more projected compared with *Cossus*, the prothorax narrowing anteriorly, neck-like. The labial palpi are longer and more distinct. The fore wing is more produced apically, longer and narrower: the outer edge less full and more oblique. The vestiture is sparse, thin, flatly laid on in body and wings. The hard chitinous tegument is less hidden, and the whole insect has a certain coleopterous aspect, reminding us of the wood-boring *Cerambycidæ*, such as *Prionus*, quite strongly. The aspect is not moth-like, but hard and chitinous. Just as there is a certain resemblance between different species feeding on a particular plant, as the pine-feeders, so do all borers have some points in common. The generic characteristics all hold good with the second species of this genus.

PRIONOXYSTUS QUERCIPERDA Fitch.

(Plate II, Fig. 4.)

This species is smaller than *robiniæ*, the ♀ expanding 46 or 47^{mm}, the ♂ about 10^{mm} less. The male hind wings seem translucent, but on holding them obliquely in certain lights the yellow tint may be seen plainly. This smaller and rarer species occurs also in Texas. It is freer from reticulations and more transparent than any other form.

We have representatives of four genera of *Cossidæ* in the United States, viz., *Hypopta*, *Cossus*, *Prionoxystus*, and *Cossula*. As to the species described under Cossus, several are incompletely described, and none are now so well known as *C. centerensis*, which has been studied by my son, Dr. Theodore P. Bailey, and myself.

COSSULA MAGNIFICA Bailey.

(Plate II, Figs. 1, 2, and 3.)

[This species was described by Dr. Bailey in Papilio for July, 1882 (Vol. II, No. 6, p. 94), with notes upon its habits. The larva bores into live-oak (*Quercus virens*) in Florida. No new matter was prepared on this species at the time of his death, and we do not consider it necessary to repeat the original description.—C. V. R.]

REPORT ON THE EXAMINATION OF RAW SILKS.

By

WILLIAM MCMURTRIE, E. M., PH. D.

Professor of Chemistry in Illinois Industrial University.

CHAMPAIGN, ILL., *February* 8, 1883.

SIR: I have just completed the examination of the samples of silk you offered for measurements of fineness and tensile strength of the fibre, and I take pleasure in submitting herewith the results we have been able to obtain, together with a brief description of the methods employed in the examination, and some considerations of the relations exhibited in the results.

Very respectfully,

WM. MCMURTRIE.

Prof. C. V. RILEY,
U. S. Entomologist.

REPORT.

Description of the material.—The material furnished for the examination about to be described consists of eight samples of cocoons of various races of silkworms, grown in this country in different localities, with different kinds of food. Each sample was inclosed in a box bearing an inscription by which the sample was distinguished, and the latter is to be found in Table I at the bottom of the column, giving the results of the measurements of the fineness of the respective samples. No measurements were made to determine the size of the cocoons or the weight of the silk they are capable of yielding, for the latter would involve the use of appliances not at our disposition. But it may be said that they were of good size, perfectly firm and uniform, clean and of good color; in fact, from all appearances, evidently of excellent quality. This constitutes all the information we have concerning the history of the cocoons.

Object of the examination.—The examination, as requested, was more to determine the quality of silk grown in the United States as compared with that obtained in European culture. For the purposes of the comparison we must refer to the published works giving the fineness and strength of the European raw silks, since we have had no material with which to determine the necessary data. From the appearance of the cocoons, however, there can be little doubt that the comparison will prove favorable to the American product.

Preparation of the material for examination.—As has already been intimated, we were provided with no special apparatus for reeling the silk from the cocoons, and specimens for the measurement of the fineness and one set for determination of the tensile strength were obtained by simply cutting open the cocoons, separating the layers by pulling them apart, and taking portions of fibre at random from each part. No attempt was made to determine in this examination differences in the quality of the fibre dependent upon the location of the part in the stratification of the cocoon, and hence the period of the spinning operation at which it was formed, both because the time at our disposal for making the examination had been limited and because this did not constitute a principal object in the examination desired. There is no doubt, however, that an investigation with this regard would furnish results of great interest and value.

The fibres separated in this way were designated as "dry;" that is, no moisture was employed in their separation. It is well known that the strength of the cocoon depends upon the glutinous character of the fibre on the instant of its issue from the spinnerets of the insect, and that the glutinous matter covering the fibre and forming a portion of its constituent structure readily softens in warm water. And it is further well known that this principle is applied practically in the industrial processes of silk reeling. To determine what influence this may have upon the fibre, we submitted a series of the cocoons to the action of warm water, and when they were sufficiently softened secured the end of the fibre and wound it upon slips of card-board, thus applying in a crude way the process of reeling. The fibre so obtained has therefore been designated as "wet." The influence of the treatment to which the fibre is subject in this process of separating it will be discussed later on, and is manifest in the results given in Table II.

Measurements of fineness.—If the fibre of raw silk be examined with a microscope of sufficiently high power, it appears to consist of a more or less flattened strip, somewhat depressed through the middle, so that its cross-section may be likened to the longitudinal section of a dumb-bell (∞), as shown in the figure. This is explained by the fact that the fibre in the glutinous condition is discharged by the worm in spinning, from the spinnerets located on the under side of the head, near the mandibles. As they pass out and are stretched by the worm in its to-and-fro motions in spinning, the two fibres are cemented together more or less firmly according to the rapidity of spinning.

Sometimes these primary fibres, as they may be termed, are separate and free from each other, and each is an almost perfect elongated cylinder. But in most cases they are firmly joined, and the two form a compact whole, constituting the raw fibre of the cocoon. It is plain, therefore, that this raw fibre is not cylindrical but ribbon-shaped, and that it has two lateral axes of different lengths, so that on some accounts a single measurement of a fibre does not represent its fineness, while at

the same time there is danger that in taking the measurements with the microscope the longer axis of the fibre may be taken in some cases, while in others the shorter axis may be inadvertently chosen. So also it may to some appear extremely desirable that in order to fairly determine the fineness of the fibre both axes should be measured, and there is much of reason in this opinion. On the other hand, if we bear in mind that the breadth of the ribbon will depend upon the diameter of the individual fibres constituting the raw fibre, it will be seen that the breadth of the fibre, or its longer lateral axis, may be accepted as a fair representation of the degree of fineness of this condition of the staple.

The method of taking the measurements of fineness is therefore as follows: The cocoon is cut open and separated into the different layers of which it is made up. A small tuft of fibres is then cut from each, taken at random. These are then cut to suitable length and mounted upon the glass object slide for microscope, immersed in Canada balsam, and covered with a thin glass circle. When the cover is in place the slide is gently warmed and laid aside for the balsam to dry and harden. When ready for the purpose each slide is placed upon the stage of the microscope, the fibres successively brought into focus, and the width of the image at its widest part measured by means of an eye-piece micrometer, which has been standardized by means of a stage micrometer graduated to centimillimeters. The relative measurement taken in this way is reduced to the absolute standard and the result entered in the record. The object of taking the width of the image at its widest part is to obviate the danger of measuring the image of the fibre turned more or less with its edge toward the eye, a difficulty that would materially vitiate the result.

In experiments made in this connection, as well as in the measurements of wools and cottons in a similar way, it has been found both advisable and necessary, in order to arrive at satisfactory conclusions concerning the property under consideration, to make measurements of at least thirty fibres in each sample. For purposes of comparison every measurement is entered upon the record, which is given in the following table:

TABLE I.—*Measurements of the fineness of raw silk.*

Catalogue number of samples.	I.	II.	III.
Actual measurements in centimillimeters.	3.00	2.625	3.25
	2.50	3.50	2.625
	3.50	4.625	2.75
	3.75	2.50	2.875
	2.875	2.625	2.75
	3.75	2.50	3.50
	3.75	2.875	2.75
	3.875	3.875	3.25
	3.50	3.25	2.75
	2.625	2.75	3.25
	2.875	2.75	2.50
	3.00	2.625	3.00
	3.50	3.00	3.00
	2.50	3.00	3.00
	3.50	3.25	3.00
	2.375	3.00	2.625
	3.75	2.25	2.50
	2.75	2.625	2.375
	3.00	2.875	2.625
	2.50	2.25	2.50
	3.125	2.75	2.50
	3.25	3.00	2.75
	2.50	2.75	2.75
	3.125	2.625	2.50
	2.625	2.875	3.00
	3.375	3.00	2.125
	2.875	2.50	2.375
	3.50	2.75	3.00
	2.375	2.50	2.75
	3.50	2.75	2.625
	2.75	2.50	2.875
	2.75	3.00	2.125
	3.25	2.875	3.00
	2.625	3.00	2.75
	3.00	2.875	2.50
	2.625	2.75	2.50
	3 125	2.625	2.50
	2.75	2.75	3.00
	2.875	2.375	2.25
	3.00	3.125	2.75
	2.00	3.25	3.25
	3.375	2.25	2.875
	3.25	3.375	3.25
	3.50	2.625	2.75
	2.50	3.25	3.00
	2.75	2.75	2.50
	3.00	2.75	3.00
	3.25	3.25	2 50
	3.00	3.25	2.50
	2.25	3.00	2.75
Average	3.015	2.878	2.748

	In centimillimeters.	In thousandths of an inch.	In fractions of an inch.	In centimillimeters.	In thousandths of an inch.	In fractions of an inch.	In centimillimeters.	In thousandths of an inch.	In fractions of an inch.
Recapitulation:									
Highest	3.875	1.5255	$\frac{1}{655}$	4.625	1.8208	$\frac{1}{549}$	3.50	1.3779	$\frac{1}{725}$
Lowest	2.00	0.7874	$\frac{1}{1269}$	2.25	0.0858	$\frac{1}{1128}$	2.125	0.8366	$\frac{1}{1195}$
Average	3.015	1.1870	$\frac{1}{843}$	2.878	1.1330	$\frac{1}{883}$	2.748	1.0818	$\frac{1}{924}$
Number of measurements above average		21			19			30	
Number of measurements below average		29			31			20	
	Yellow Japanese; mulberry.			Yellow Japanese; Osage orange.			Riley's yellow Japanese; Osage orange; 11 years.		

TABLE I.—*Measurements of the fineness of raw silk*—Continued.

Catalogue number of samples.	IV.	V. Yellow.	V. White.
Actual measurements in centimillimeters.	2.375	2.125	2.00
	2.50	2.50	2.50
	2.00	2.50	3.00
	2.75	2.50	2.75
	2.00	2.375	2.625
	2.50	2.25	2.25
	2.75	2.375	2.50
	2.50	2.50	2.25
	2.50	2.25	3.00
	2.25	2.50	2.50
	2.75	2.50	2.50
	2.875	2.25	3.00
	2.625	1.875	2.25
	2.125	2.125	2.375
	2.375	2.75	2.00
	2.75	2.50	2.50
	3.00	2.50	2.00
	2.375	2.00	2.50
	2.75	2.75	2.50
	2.25	2.25	2.25
	2.75	2.875	2.50
	2.75	2.50	2.125
	2.50	2.375	3.00
	2.75	2.50	3.25
	2.25	2.25	2.375
	2.125	2.50	2.75
	2.625	2.50	2.50
	2.75	2.375	3.00
	2.375	2.50	2.25
	2.625	2.75	2.50
	2.50	2.50	2.50
	2.75	3.25	2.125
	2.625	3.00	2.125
	2.75	1.875	1.875
	2.50	1.75	2.75
	2.375	2.75	2.25
	2.50	2.375	2.50
	2.50	2.75	2.75
	2.25	2.625	2.375
	3.25	2.375	2.25
	2.625	2.50	2.50
	2.00	2.75	3.25
	2.50	2.25	2.75
	2.125	3.00	3.125
	2.625	2.75	3.00
	2.50	2.625	2.25
	2.75	2.50	2.25
	2.375	2.00	2.75
	2.50	2.25	3.00
	2.375	2.875	2.50
Average	2.513	2.465	2.528

	In centimillimeters.	In thousandths of an inch.	In fractions of an inch.	In centimillimeters.	In thousandths of an inch.	In fractions of an inch.	In centimillimeters.	In thousandths of an inch.	In fractions of an inch.
Recapitulation:									
Highest	3.25	1.2735	$\frac{1}{781}$	3.25	1.2735	$\frac{1}{781}$	3.25	1.2735	$\frac{1}{781}$
Lowest	2.00	0.7874	$\frac{1}{1269}$	1.75	0.6889	$\frac{1}{1451}$	1.875	0.7380	$\frac{1}{1354}$
Average	2.513	0.9893	$\frac{1}{1010}$	2.465	0.9704	$\frac{1}{1030}$	2.528	0.9952	$\frac{1}{1004}$
Number of measurements above average		21			30			17	
Number of measurements below average		29			20			33	
	Riley's white Japanese; Osage orange; 11 years.			Fasnach's black Thibet.			Fasnach's black Thibet.		

TABLE I.—*Measurements of the fineness of raw silk*—Continued.

Catalogue number of samples.	VI.	VII.	VIII.
Actual measurements in centimillimeters.	2.50 2.50 3.125 2.00 3.125 3.00 3.00 2.75 2.125 2.75 2.125 3.50 2.75 2.25 2.875 3.00 2.25 3.00 2.75 2.375 2.50 3.25 3.375 2.50 3.00 3.00 2.625 2.75 3.50 2.875 3.25 2.875 2.50 2.50 2.875 3.25 2.75 3.50 2.875 3.25 3.50 3.00 3.00 3.00 2.50 3.00 2.50 2.75	3.50 2.75 3.00 3.00 3.25 2.625 2.50 3.00 3.00 3.25 3.50 3.375 2.50 2.875 2.75 3.50 3.00 3.25 2.50 2.75 3.50 3.50 3.00 3.25 2.875 3.25 3.00 2.875 3.00 2.75 2.875 2.75 4.25 3.25 2.50 3.125 2.75 2.25 2.75 3.50 3.25 3.00 2.75 3.00 3.50 2.75 3.125 3.25 3.375	2.75 2.00 2.00 2.50 2.50 3.00 2.50 2.625 2.375 2.50 2.375 3.50 2.00 2.50 2.50 2.25 2.625 2.375 2.75 2.50 2.00 2.50 2.50 2.25 2.25 2.50 2.50 2.75 2.375 2.50 2.50 2.00 3.00 2.25 2.00 3.25 2.25 2.25 2.75 2.50 2.25 2.625 2.75 3.00 2.25 2.375 3.00 2.50 2.25 2.25
Average	2.86	3.038	2.485

	In centimillimeters.	In thousandths of an inch.	In fractions of an inch.	In centimillimeters.	In thousandths of an inch.	In fractions of an inch.	In centimillimeters.	In thousandths of an inch.	In fractions of an inch.
Recapitulation:									
Highest	3.50	1.3779	$\frac{1}{725}$	4.25	1.6732	$\frac{1}{597}$	3.50	1.3779	$\frac{1}{725}$
Lowest	2.00	0.7874	$\frac{1}{1269}$	2.25	0.8858	$\frac{1}{1128}$	2.00	0.7874	$\frac{1}{1269}$
Average	2.86	1.1259	$\frac{1}{888}$	3.038	1.960	$\frac{1}{833}$	2.485	0.9783	$\frac{1}{1021}$
Number of measurements above average	27			20			29		
Number of measurements below average	23			30			21		
	Crozier's, French, from Cevennes.			Crozier's, French Black. Worms white.			Croziers, French Black. Worms dark.		

The table will for the most part explain itself. The records of actual measurements are stated in centimillimeters, and at the foot of each column of these is given the average of the thirty measurements represented in each one respectively.

In the recapitulation we give reductions of these averages to thousandths of an inch, and to fractions of an inch expressed in the vulgar fraction, in order that the figures may be more easily comprehended by all to whom they may be presented. In the same section we have given, similarly reduced, the highest and lowest measurements taken on each sample, while in down lines will be found a series of figures showing the number of measurements found above and below the average respectively. These serve to show at a glance the range of the measurement, and therefore express the degree of evenness and regularity found throughout the length of the fibre of each sample. They will therefore serve, to some extent, as an indication of the comparative value of the several samples.

At the extreme bottom of each column is given a copy of the inscription found on the box inclosing the sample represented. For the better comparison of the several samples we may submit the following condensed table giving the averages of the measurements stated in centimillimetres and thousandths of an inch:

Number of samples.	Average measurements in centimillimeters.	Average measurements in thousandths of inch.
I	3.015	1.1870
II	2.878	1.1330
III	2.748	1.0818
IV	2.513	0.9893
V.—Yellow	2.465	0.9724
V.—White	2.528	0.9952
VI	2.86	1.1259
VII	3.038	1.1960
VIII	2.485	0.9783

The differences here shown appear to be sufficiently wide to illustrate any differences in the condition of feeding and management to which the worms may have been subject during their development, but the data we have will not warrant our entering into any discussion of these interesting relations. There can be no doubt, however, that the complete history of the worms will furnish material for exceedingly interesting and valuable comparisons in this particular.

Measurements of strength and stretch.—The determinations of the tensile strength of the fibres were effected by the aid of a dynamometer specially constructed for use in the examination of wools and cottons, and described in "A Preliminary Report on the Examination of Cotton" submitted to the Honorable Commissioner of Agriculture in 1882. This

instrument is so constructed that the strain to which the fibre is subjected to break it, and the stretch it sustains previous to rupture, are simultaneously taken and recorded, and we have, therefore, to present in this connection two sets of results.

In making these tests the following method was employed: In the first place the cocoons were cut open and their layers separated, or they were submitted to the action of hot water and the fibres wound off upon pieces of card-board, each process furnishing the "dry" and "wet" specimens respectively described in a preceding paragraph. From the loose fibre thus obtained sections of suitable length were taken at random for the individual tests, the "*wet*" specimens having been previously thoroughly dried. The two clamps holding the fibres in the instrument during the tests were carefully set at a distance of 20 millimeters apart, so that this distance represents the length of the fibre submitted to the strain. Experiments with woolen fibres showed this distance to give the most uniform and satisfactory results, and is, therefore, accepted as a standard for all our work. Although no special experiments were made with this regard on the silk examined, there is little doubt that it would be found equally satisfactory.

In this part of the examination as in the measurements of fineness, we have adopted 30 as the best number of fibres to be tested to secure a satisfactory average, and as before, each separate result obtained was entered upon the record to be employed in any comparisons that it may appear to be desirable to name. For their more ready comparison the results obtained with the "*dry*" and "*wet*" specimens, respectively, are placed side by side. The following table contains the results we have obtained:

TABLE II.—MEASUREMENT OF STRENGTH OF RAW SILK.

Catalogue number of samples	I.—Dry.				I.—Wet.				II.—Dry.				II.—Wet.			
	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.
Actual measurements in grams and millimeters.	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*
	2.75	2.25	10.50	2.50	10.25	2.00	10.00	3.25	3.00	3.75	11.75	4.50	10.75	1.50	16.00	3.50
	3.75	3.00	10.25	3.00	10.50	3.00	14.00	1.75	3.75	2.75	12.50	5.25	12.50	1.50	14.25	2.00
	3.50	3.75	11.25	3.75	10.00	2.75	11.00	1.75	2.50	3.25	11.50	4.25	15.00	2.25	12.50	1.25
	2.75	2.00	11.75	4.75	11.25	2.25	11.00	3.00	4.25	4.00	11.25	4.25	13.50	3.25	14.00	2.50
	4.50	2.25	8.75	3.25	13.50	3.75	11.75	3.50	5.00	3.00	11.00	4.00	14.25	2.75	13.75	3.75
	9.00	2.00	9.50	3.75	13.00	4.00	11.75	3.50	5.25	4.00	11.00	5.00	12.50	2.50	12.25	2.75
	11.25	1.75	8.00	3.00	10.00	2.00	10.00	2.25	10.50	2.25	11.50	4.75	10.50	1.25	14.00	4.00
	10.50	4.25	8.25	2.50	12.75	3.50	10.50	3.25	11.00	3.00	11.25	4.25	15.50	4.50	10.75	3.00
	11.25	3.75	8.00	3.00	12.25	2.00	13.50	3.50	5.25	4.75	11.50	4.50	11.00	3.75	11.75	2.00
	8.75	2.50	8.25	3.25	12.25	1.25	11.00	3.25	8.00	3.25	10.75	5.00	10.00	2.25	10.75	1.75
	13.00	2.00	6.00	1.50	11.50	3.75	12.00	4.00	11.00	3.75	4.25	4.00	12.00	3.00	11.00	3.25
	9.25	3.00	8.00	2.50	11.75	4.75	12.50	4.75	11.00	3.75	4.25	5.00	11.50	3.00	11.25	3.25
	12.00	2.25	5.50	1.75	10.00	2.25	10.00	2.25	11.25	3.00	4.00	4.25	10.50	2.00	12.75	1.25
	10.00	3.00	6.25	2.25	11.00	3.25	12.50	3.25	11.00	3.75	3.50	2.50	10.50	1.25	12.00	1.75
	12.00	4.75	6.25	2.00	10.00	3.25	11.25	3.75	11.50	4.75	3.25	2.75	12.50	1.25	12.25	1.25
Totals	124.25	42.50	126.50	42.75	170.00	43.75	172.75	47.00	114.25	53.00	133.25	64.25	182.50	36.00	189.25	37.25

RECAPITULATION.

	Strain.		Stretch.		Strain.		Stretch.		Strain.		Stretch.		Strain.		Stretch.	
	Grams.	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains*	*mm.*	*Per ct.*
Highest	13.00	200.65	4.75	23.75	14.00	216.08	4.75	23.75	12.50	192.93	5.25	26.25	16.00	246.95	4.50	22.50
Lowest	2.75	42.44	1.50	7.50	10.00	154.35	1.25	6.25	2.50	38.59	2.25	11.25	10.00	154.35	1.25	6.25
Average	8.36	129.03	2.84	14.21	11.43	176.42	3.03	15.15	8.25	127.34	3.91	19.55	12.39	191.23	2.44	12.20

	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.
No. of tests above average	16	15	14	17	17	17	14	15
No. of tests below average	14	15	16	13	13	13	16	15

TABLE II.—MEASUREMENT OF STRENGTH OF RAW SILK—Continued.

Catalogue number of samples	III.—Dry.				III.—Wet.				IV.—Dry.				IV.—Wet.			
	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.
	Grams.	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams*	*mm.*
Actual measurements in grams and millimeters	2.50	4.00	4.00	2.75	9.25	2.25	10.50	2.25	2.50	1.00	8.50	3.25	10.25	3.50	12.25	3.75
	2.75	3.50	5.50	1.00	12.25	1.75	10.00	3.00	3.50	2.75	8.50	2.75	8.00	1.75	11.00	3.50
	2.00	3.75	6.25	2.25	8.00	1.75	9.75	1.25	3.75	3.75	9.75	3.50	8.50	3.00	9.25	2.25
	2.75	3.00	3.25	2.25	10.75	3.00	9.75	1.00	3.25	3.00	8.00	2.50	9.75	4.00	10.25	2.25
	2.50	3.25	6.25	1.50	10.00	3.25	5.00	1.75	4.00	4.00	8.00	2.75	9.00	2.25	9.25	4.25
	7.00	3.50	3.75	3.75	7.75	1.25	5.25	2.25	9.50	3.50	7.50	2.50	8.00	2.50	8.00	2.75
	9.25	5.00	4.00	3.25	11.50	1.75	11.50	1.75	11.00	5.00	6.00	2.00	9.25	2.25	8.25	1.50
	9.00	2.00	3.50	3.50	10.75	1.50	10.25	1.25	10.00	3.75	9.00	1.50	9.75	3.25	10.75	4.75
	9.75	2.50	4.50	1.75	5.50	1.25	11.75	1.75	9.00	3.00	8.00	2.25	9.00	3.00	9.00	3.75
	10.00	4.00	5.25	1.75	10.25	2.50	6.25	1.25	10.00	3.75	8.25	3.50	9.25	3.00	10.00	3.75
	10.00	2.75	3.25	3.25	8.75	1.75	10.25	2.75	11.75	1.75	6.00	2.75	9.50	1.25	10.00	3.25
	10.25	3.75	5.25	1.75	6.75	1.00	10.00	2.00	11.25	1.25	5.00	1.75	9.00	2.25	8.25	3.00
	10.50	2.00	5.00	1.75	8.00	1.50	10.00	1.75	9.75	2.25	6.00	2.50	8.50	2.75	8.75	4.00
	8.75	3.50	4.50	1.25	10.50	2.25	7.75	1.00	10.50	2.75	5.50	2.25	11.00	4.00	7.50	2.75
	9.00	3.00	3.25	1.00	12.50	2.50	10.25	2.00	10.25	3.00	6.50	3.75	10.50	3.00	8.00	2.75
Total	106.00	49.50	67.50	32.75	142.50	29.25	138.25	27.00	120.00	44.50	110.50	39.50	139.25	41.75	140.50	48.25

RECAPITULATION.

	Strain.		Stretch.		Strain.		Stretch.		Strain.		Stretch.		Strain.		Stretch.	
	Grams.	*Grains*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*
Highest	10.50	162.06	5.00	25.00	12.50	192.93	3.25	16.25	11.75	181.36	5.00	25.00	12.25	189.07	4.75	23.75
Lowest	2.00	30.87	1.00	5.00	5.00	77.17	1.00	5.00	2.50	38.59	1.00	5.00	7.50	115.76	1.25	6.25
Average	5.78	89.21	2.74	13.70	9.36	144.47	1.88	9.40	7.68	118.54	2.80	14.00	9.33	144.00	3.00	15.00

	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.
No. of tests above average	12	17	19	12	18	13	12	12
No. of tests below average	18	13	11	18	12	17	18	18

TABLE II.—MEASUREMENT OF STRENGTH OF RAW SILK—Continued.

Catalogue number of samples.	V.—Dry yellow, split fibres.				V.—Dry white, split fibres.				V.—Dry yellow.				V.—Wet yellow.			
	Strain.		Stretch.		Strain.		Stretch.		Strain.		Stretch.		Strain.		Stretch.	
	Grams.	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*
Actual measurements in grams and millimeters.	5.50	3.75	4.50	3.25	4.50	3.25	4.00	1.50	5.50	2.50	10.00	3.50	6.25	1.50	8.00	3.50
	5.00	3.25	4.00	3.75	4.25	2.75	3.25	1.75	6.75	4.75	9.50	3.00	6.75	2.00	7.00	3.25
	4.50	1.25	4.00	4.00	3.00	1.00	5.25	3.25	6.00	2.75	11.00	4.25	7.00	1.50	8.00	2.00
	5.50	2.75	4.50	2.75	3.00	1.00	3.50	1.25	5.75	4.25	9.00	2.75	7.75	1.75	6.50	2.00
	6.00	1.25	4.50	3.00	3.25	1.50	3.00	3.00	5.00	2.25	10.50	4.00	6.00	2.00	8.25	3.25
	4.00	3.75	4.25	5.00	4.50	4.75	6.50	2.00	8.75	3.25	9.50	5.00	12.25	1.75	7.00	2.25
	4.00	2.75	5.00	4.50	4.00	2.75	4.75	1.00	8.75	4.75	9.00	4.50	6.25	2.50	9.50	1.75
	5.00	5.25	4.00	4.50	3.25	1.50	5.50	2.00	9.50	4.00	9.25	4.50	8.75	3.25	10.50	3.75
	5.00	4.75	4.00	3.25	4.50	3.75	3.50	2.25	9.25	2.00	6.00	1.25	8.75	3.00	8.75	3.00
	4.50	5.25	4.00	3.25	3.50	2.25	5.00	1.50	8.00	2.25	5.25	3.25	6.50	1.75	7.00	3.00
	3.50	3.50	3.25	2.75	4.00	4.75	2.50	3.25	11.00	4.75	5.00	2.00	9.25	2.75	11.00	2.00
	3.50	2.75	3.75	3.25	3.25	3.00	5.25	2.50	9.25	4.25	5.25	2.25	6.75	1.25	6.00	1.75
	3.75	3.00	3.25	2.25	3.25	3.00	2.25	2.00	12.00	1.75	5.75	2.25	7.00	1.75	7.50	1.75
	5.00	5.50	2.75	3.25	4.75	3.50	2.25	2.25	10.00	3.25	9.00	4.00	8.25	1.25	7.75	2.25
	4.25	3.25	3.75	3.25	3.75	3.00	2.25	3.75	10.75	2.75	9.25	4.25	7.50	2.25	6.25	1.75
Total	69.00	52.00	59.50	52.00	56.75	41.75	58.75	33.25	126.25	49.50	123.25	50.75	115.00	30.25	119.00	37.25

RECAPITULATION.

	Strain.		Stretch.		Strain.		Stretch.		Strain.		Stretch.		Strain.		Stretch.	
	Grams.	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*
Highest	6.00	92.61	5.50	27.50	6.50	100.32	4.75	23.75	12.00	185.22	5.00	25.00	12.25	189.07	3.75	18.75
Lowest	2.75	42.44	1.25	6.25	2.25	34.73	1.00	5.00	5.00	77.17	1.25	6.25	6.00	92.61	1.25	6.25
Average	4.28	66.06	3.47	17.35	3.85	59.42	2.50	12.50	8.32	128.42	3.34	16.70	7.80	120.39	2.25	11.25

	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.
No. of tests above average	14	12	14	14	19	14	12	13
No. of tests below average	16	18	16	15	11	16	18	17

TABLE II.—MEASUREMENT OF STRENGTH OF RAW SILK—Continued.

Catalogue number of samples.	V.—Dry white.				V.—Wet white.				VI.—Dry.				VI. Wet.			
	Strain.		Stretch.		Strain.		Stretch.		Strain.		Stretch.		Strain.		Stretch.	
	Grams.	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*
Actual measurements in grams and millimeters.	4.00	2.25	9.75	3.00	11.00	2.75	6.75	2.75	10.50	4.00	15.50	5.00	12.00	2.00	13.00	2.00
	4.25	3.25	5.50	2.00	10.50	4.00	10.50	2.75	10.50	4.75	15.50	4.25	11.25	2.75	12.00	3.50
	4.00	1.75	5.75	2.25	11.75	2.00	9.00	2.00	8.00	2.50	15.00	4.25	12.25	3.00	13.25	1.25
	3.75	2.25	10.00	3.00	11.25	2.00	10.25	2.25	11.00	4.00	14.00	3.25	12.00	2.25	12.25	3.25
	3.75	2.25	6.50	1.75	11.25	3.00	9.50	1.75	8.00	1.25	15.00	4.25	11.75	3.00	12.50	4.25
	8.00	3.25	5.25	1.75	9.75	1.75	11.00	2.25	16.00	1.75	14.50	4.25	10.25	2.50	10.50	2.00
	7.75	3.00	6.00	1.25	11.25	2.75	8.00	1.75	17.25	3.25	13.00	3.75	12.00	1.25	13.00	2.00
	9.50	3.25	4.00	1.50	11.00	3.50	11.00	3.00	16.00	5.25	13.25	3.75	11.00	3.00	8.00	1.75
	9.00	3.25	4.25	1.25	11.25	2.75	9.25	1.75	15.50	4.00	12.50	2.25	10.25	2.00	10.50	2.75
	7.00	4.00	6.25	2.75	11.00	4.00	10.00	3.75	13.50	3.75	12.25	2.25	11.00	3.00	8.00	2.50
	8.50	3.50	4.00	1.50	6.75	1.75	8.00	1.75	11.00	1.75	5.50	1.25	9.00	2.25	12.00	3.25
	8.50	2.75	5.25	2.25	7.00	1.25	9.25	2.25	13.00	2.50	7.25	1.25	8.00	1.75	12.00	3.75
	8.00	2.50	4.50	1.25	8.00	1.75	10.25	1.75	11.75	2.75	5.25	1.00	8.25	2.75	11.25	3.25
	7.75	1.75	4.25	2.25	10.00	3.00	8.75	2.50	13.00	3.50	7.50	2.00	10.00	2.25	13.50	3.75
	8.50	3.50	5.25	2.25	11.00	3.00	10.00	2.75	14.00	3.00	6.25	1.50	11.50	3.00	13.00	3.50
Total	102.25	42.50	86.50	30.00	152.75	39.25	141.50	35.00	189.00	48.00	172.25	44.25	160.50	36.75	174.75	42.75

RECAPITULATION.

	Strain.		Stretch.		Strain.		Stretch.		Strain.		Stretch.		Strain.		Stretch.	
	Grams.	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*
Highest	10.00	154.35	4.00	20.00	11.75	181.36	4.00	20.00	17.25	266.25	5.25	26.25	13.50	208.37	4.25	21.25
Lowest	3.75	57.88	1.25	6.25	6.75	104.18	1.25	6.25	5.25	81.03	1.00	5.00	8.00	123.48	1.25	6.25
Average	6.29	97.08	2.42	12.10	9.81	151.41	2.48	12.40	12.04	185.83	3.08	15.40	11.18	172.56	2.65	13.25

	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.
No. of tests above average	13	13	18	15	18	17	18	16
No. of tests below average	17	17	12	15	12	13	12	14

TABLE II.—MEASUREMENT OF STRENGTH OF RAW SILK—Continued.

Catalogue number of samples.	VII.—Dry.		VII.—Wet.		VIII.—Dry.		VIII.—Wet.	
	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.
	Grams.	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*	*Grams.*	*mm.*
Actual measurements in grams and millimeters.	8.50	6.00	10.00	1.25	8.25	4.25	5.25	1.75
	8.00	4.00	11.00	2.75	7.75	3.25	6.25	1.75
	8.25	3.25	11.25	2.00	8.25	4.00	6.50	3.25
	9.25	2.75	10.25	4.00	7.75	3.50	7.50	3.50
	7.75	4.25	11.00	3.25	8.75	3.25	7.75	2.25
	13.00	4.00	12.00	2.75	8.75	3.25	7.50	2.25
	13.00	3.25	10.50	1.75	9.75	2.75	6.75	3.00
	12.25	2.75	10.75	1.50	9.00	1.50	7.50	2.25
	11.50	2.75	12.50	2.00	8.50	1.25	7.00	1.25
	12.25	3.00	11.25	2.00	9.50	3.75	7.00	1.75
	14.00	4.50	10.00	2.50	9.25	3.50	8.00	3.00
	12.25	3.50	9.00	2.00	10.00	4.25	7.75	1.75
	12.50	3.25	10.00	3.00	12.00	4.25	6.75	3.00
	15.00	5.00	10.75	2.75	10.25	4.00	6.25	2.25
	14.50	3.75	14.00	4.00	10.50	4.00	7.25	1.75
					10.00	3.25	7.00	1.75
Total	172.00	56.00	164.25	37.50	139.50	50.75	104.50	35.25
	114.75	51.25	167.25	38.75	118.25	41.75	104.50	37.25

RECAPITULATION.

	Strain.		Stretch.		Strain.		Stretch.		Strain.		Stretch.		Strain.		Stretch.	
	Grams.	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*	*Grams.*	*Grains.*	*mm.*	*Per ct.*
Highest	15.00	231.52	6.00	30.00	14.00	216.08	4.00	20.00	10.50	162.06	4.25	21.25	8.50	131.19	4.00	20.00
Lowest	5.50	84.89	2.25	11.25	9.00	139.91	1.25	6.25	5.00	77.17	1.25	6.25	5.00	77.17	1.25	6.25
Average	9.56	147.55	3.58	17.90	11.05	170.55	2.54	12.70	8.59	132.58	3.08	15.40	6.97	107.58	2.42	12.10

	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.	Strain.	Stretch.
No. of tests above average	12	12	12	14	16	16	19	10
No. of tests below average	18	18	18	16	14	14	11	20

Here, as before, we have given the actual measurements taken, the strains being stated in grams and the stretch in millimeters and per cents. In the recapitulation we have prepared a statement showing the averages of all the measurements taken with each sample respectively, as well as the highest and lowest results obtained in each, the strain in each case being reduced to grains and the stretch to per cents of the length. This will make the figures more intelligible to all who may be interested in them, and will render a comparison much more easy. In the lower lines we find a statement showing the number of measurements found above or below the average, as the case may be, for each sample.

In explaining the method of measuring the fineness reference has been made to the peculiar structure of the fibre, resulting from the mode of its production. This structure was decidedly marked in "dry" No. V. Here very many of the fibres were split either before the test or became split by the strain or at the instant of rupture. We find upon comparison of the results obtained in the tests of the split fibres in tests of whole fibres from the same cocoons that the latter are very considerably stronger than the former, though as regards the percentage of stretch there appears to be no very material difference between the two. And another peculiarity in the relations of the two is that the strength of the whole fibre appears from the averages to be about double that of the split fibres. Let us bring these averages together for more ready comparison. It will suffice to express the strain as grams:

	Split. grams.	Whole, grams.
V (dry yellow)	4.28	8.32
V (dry white)	3.85	6.29

On the other hand it may be mentioned that the uniformity in the strength of the fibres as regards the strain they are able to bear previous to rupture, as represented in the number of measurements found above and below the averages respectively, appears to be greater in the split fibres. The most important difference appears therefore to be in the strain representing the strength of the fibre, showing the importance of the more complete cementation of the fibres together as they issue from the spinnerets of the worms; and we may also learn from this something of the importance of maintaining the healthy and vigorous condition of the worms during their development, and more especially during the period when they are spinning their cocoons. The vigor and activity of the insects at the time may be very materially stimulated by careful regulation of the temperature, ventilation, and light, and not only the value of the fibre with this regard, but the condition and appearance of the cocoon, upon which its market value largely depends, may be modified by these relations. In this rather critical

period of the insect's existence, when from the circumstances the extreme care maintained throughout its development is likely to be relaxed, the silk-grower should be particularly watchful and observe the greatest care in keeping up the most favored conditions for the changes the young insect is about to undergo during the period here referred to.

These considerations will also serve to attract attention to the important influence of the methods employed industrially in reeling the silk from the cocoon upon the value of the staple. We have seen that when the separate fibres issuing from the spinnerets of the worm are fairly cemented together they are stronger than when they are not thus combined. And if we look over the Table II, given above, we shall find that when the cocoons have been wet, or have been soaked in hot water in order to separate the fibre, the latter as a general rule is stronger than when it has been separated dry. In the process of reeling the fibre becomes thoroughly soaked and saturated with water, so that the glutinous character becomes perfectly developed. As a result the primary fibres are more completely cemented together, while the ultimate fibres brought into contact passing to the reel are combined so perfectly that a maximum of strength must be secured. The influences of moisture upon the strength of the fibres will be noted upon comparison of the averages given in Table II. For convenience in making this comparison we have collected the necessary figures in the following table:

No. of samples.	Average strain required for rupture.	
	Dry reeling.	Wet reeling.
I	8.36	11.43
II	8.25	12.39
III	5.78	9.36
IV	7.68	9.33
V (yellow)	8.32	7.80
V (white)	6.29	9.81
VI	12.04	11.18
VII	9.56	11.05
VIII	8.59	6.97

We find here that, as a general rule, the higher results are in favor of the fibres that were reeled wet. The exceptions found are in samples V (yellow), VI, and VIII, and these may doubtless be explained by facts in the history of which we are not in possession.

In the table of results obtained with the dynamometer we have, as in the preceding relating to fineness, given in the recapitulation the highest and lowest as well as the average of the measurements taken. Below these may be found statements showing the number of measurements found above and below the average respectively. These figures serve to show the uniformity of the fibres with regard to the qualities represented. The extension of the fibre under the strain necesssary to

rupture is expressed in millimeters in a length of twenty millimeters of fibre, as well as in per cents. No special experiments were made to determine the limits of elasticity, and though the stretch will vary somewhat with the length of fibre held between the clamps of the instrument, limiting thus the character of the results, yet for the purpose of comparison the figures we have given will prove amply sufficient, and they will clearly show the differences in the quality and value of the samples submitted to examination.

Other qualities of the fibre and the cocoons have suggested themselves for investigation in the course of this work, but their examination has been precluded by the limited time at our disposal for the present study of this staple. We, therefore, submit these results in the hope that they may serve the ends desired.

EXPLANATION TO PLATES.

PLATE I.

Cossus centerensis.

1. Group of eggs as deposited, natural size.
2. Egg magnified 9 diameters.
3. Caterpillar from time of emerging to October 14—four months' growth
4. Caterpillar of one year and four months' growth.
5. Caterpillar of two years and four months' growth.
6. Mature caterpillar, three years old; ready to pupate.
7. Pupal cell.
8. Male pupa.
9. Female pupa.
10. Male Cossus, unspread.
11. Female Cossus.
12. Female Cossus, showing ovipositor.

PLATE II.

Cossula magnifica.

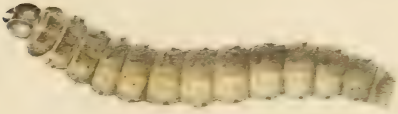
1. Pupa case of Cossula magnifica.
2. Cossula magnifica. Male.
3. Cossula magnifica. Female.
4. Cossus querciperda. Male.
5. Cossus querciperda. Female.
6. Cossus angrezi. Female.

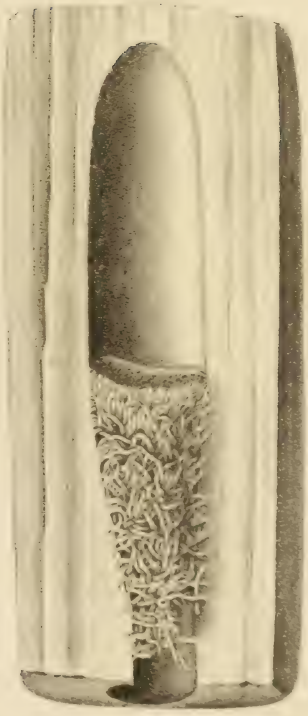
PLATE III.

Silk fibres.

1. Fibre of white Cevennes race.
2. Fibre of Crozier's black race.

(Both figures magnified 240 diameters.)





Cossus centerensis.

2

3

1

4

5

6

1, 2, 3. COSSULA MAGNIFICA. 4, 5. COSSUS QUERCIPERDA. 6. COSSUS ANGREZI.

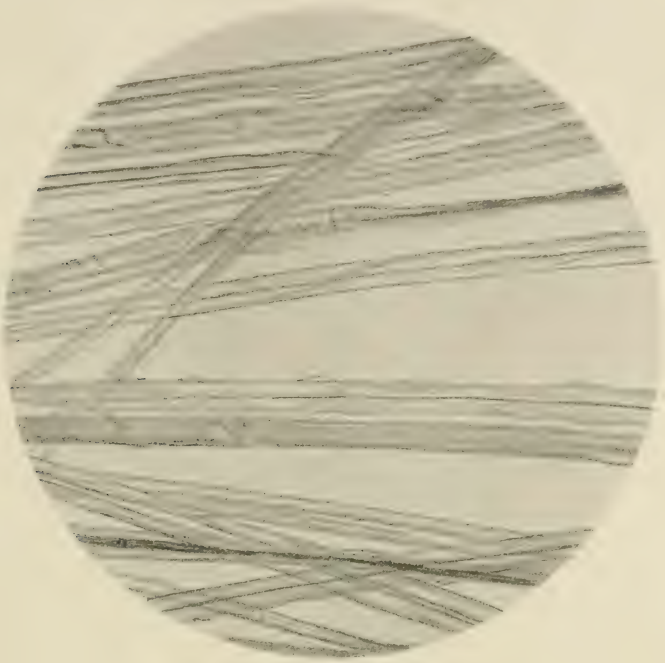


Fig. 1.

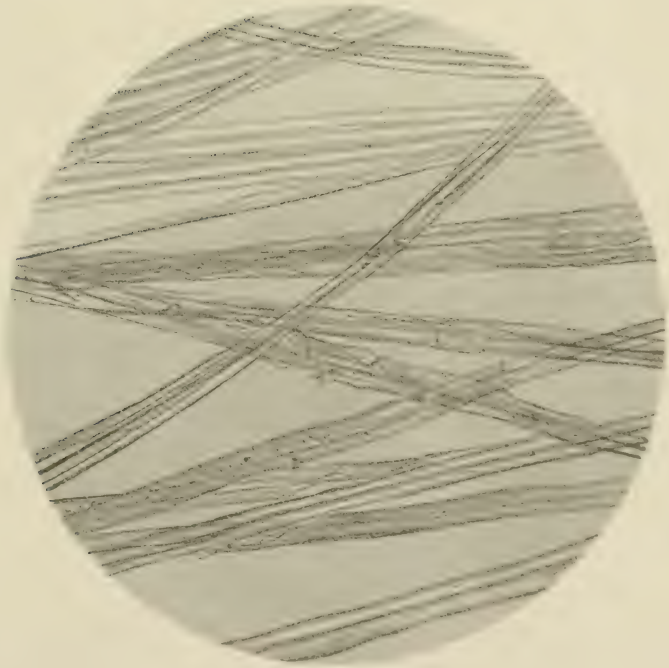


Fig. 2.

SILK FIBRE

A. Boos & Co. Lithographers, Baltimore.

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